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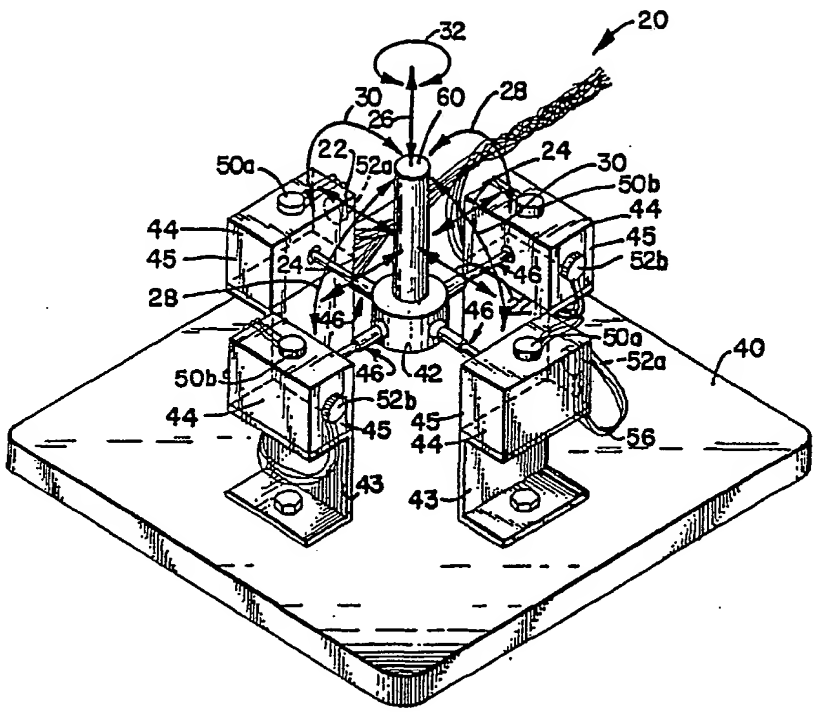
(54) Title: JOYSTICK APPARATUS HAVING SIX DEGREES FREEDOM OF MOTION



(57) Abstract

A joystick apparatus (20) having six degrees of motion, namely, translational motion along X, Y and Z axes and rotational motion about the X, Y and Z axes.

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JOYSTICK APPARATUS HAVING SIX DEGREES FREEDOM OF MOTION

This application is a continuation-in-part of serial number 010,851 filed February 4, 1987.

Background of the Invention

The present invention relates to a user input device, hereafter referred to as a joystick apparatus, capable of being moved in all directions so as to have six degrees freedom of motion, namely, translational motion along x, y, and z axes, and rotational motion about x, y, and z axes. More particularly, the present invention provides a joystick apparatus with significant advantages in manipulating three-dimensional computer generated images on display media as well as manipulation of objects in three-dimensional space.

Joysticks are typically electrically interconnected to computer control systems for permitting manual input of positioning or other information. Joysticks have long been used to control and manipulate objects and images on a display medium. For example, in electronic arcade games, joysticks are typically used to control two-dimensional movement of images on a display medium. Such a joystick may be defined as a control device comprising a handle with freedom of motion in all directions of a plane; i.e., translational movement along x and y axes of the plane. Joysticks have also been used to control three-dimensional movement of objects and movement of images on display media. Such joysticks typically comprise a vertically mounted stick or column which can be moved in all directions of a plane and rotated about an axis perpendicular to the plane. U.S. Patent Nos. 4,046,005; 4,217,569; and 4,468,688 are examples of such joysticks. When moved backward, forward, or sideways, x and y coordinate values are typically varied, with the z coordinate value being varied whenever the joystick is rotated clockwise or counterclockwise. Typically, the x, y, and z coordinate values are stored in corresponding x, y

and z registers which are periodically scanned by a host computer system, since joysticks normally do not generate interrupts when they are activated. However, some joysticks do generate an interrupt which is transmitted to the host computer system whenever the joystick is activated by moving the joystick handle. The values of the x, y, and z input registers are used by the host computer system to control orientation and movement of the three-dimensional images on the display medium. Numerous efforts have been made at improving joystick performance and interaction with a user. The following patent references disclose some of these efforts:

PATENT NO.	PATENTEE	ISSUE DATE
4,046,005	Goroski	Sept. 6, 1977
4,161,726	Burson et al.	July 17, 1979
4,217,569	Nejedly et al.	Aug. 12, 1980
4,382,166	Kim	May 3, 1983
4,468,688	Gabriel et al.	Aug. 28, 1984
4,536,746	Gobeli	Aug. 20, 1985

The above patent references disclose joysticks having three degrees freedom of motion, namely, translational motion relative to the x and y axes, and rotational movement about the z axis. Although some of the references may provide for three-dimensional control of images on a display medium, they do not provide a joystick apparatus having six degrees freedom of motion corresponding to the six degrees freedom of motion possible in three-dimensional space. Some joysticks utilize force sensing as opposed to movement sensing. However, these devices often do not have the desired accuracy and intuitiveness. Although, arguably there is some minute amount of movement present in force sensing, it is insufficient to provide useful intuitive feedback to the user.

The present invention solves these problems and others associated with existing input devices, providing for user control and manipulation of objects in three-dimensional space and three-dimensional computer generated images in a very intuitive and interactive way by manipulation of the joystick apparatus in a manner which corresponds to the manipulation of a three-dimensional object in three dimensional space.

Summary of the Invention

The present invention relates to a joystick apparatus having a central body means supported for translational and rotational movement in any direction within a limited three-dimensional space. The joystick apparatus includes sensor means spaced apart from the central body means for sensing movement of the central body means.

In one embodiment, the present invention also relates to a computer graphics input device used for controlling movement of an image on a computer graphics display terminal, the input device including body means supported for translational and rotational movement in any direction within a limited three-dimensional space and transducer means for sensing movement of the body means and converting the sensed movement into output signals representative of the sensed movement.

In one embodiment, the sensor means are slidably mounted for linear movement generally away and toward the central body.

In yet other embodiments, the central body is connected to stationary sensor means by telescoping means.

In one embodiment, the present invention relates to a joystick apparatus having a central body portion with six degrees freedom of motion, namely, translational motion along x, y, and z axes and rotational motion about x, y, and z axes. The joystick apparatus includes a support

base. The joystick apparatus further includes a central body portion interconnected to at least three, two-dimensional joystick apparatus each having a base portion and control handle means interconnected to the base portion so as to have two degrees of motion. A two-dimensional joystick apparatus includes linear sensor means, typically there being two such linear sensors present, for sensing movement of the control handle means and for providing corresponding output signals. The control handle means is interconnected to the central body portion by universal joint means for universal movement and including adjustable length means for providing the handle means with adjustable length so as to enable adjustable displacement between the central body portion and the base portion of the two-dimensional joystick apparatus, whereby the central body portion is provided with six degrees of motion, namely, translational motion along the x, y, and z axes and rotational movement about the x, y, and z axes. The universal joint means is disposed about the central body portion at predetermined locations. A main control handle means extends from the central body portion for facilitating user manipulation of the central body portion.

It will be appreciated that the joystick apparatus might include force transducer sensors as opposed to motion transducer sensors. Movement from one location to another in three-dimensional space has both a magnitude component and a direction component. The direction component of any such movement in three-dimensional space can be defined in terms of its x, y, and z components; i.e., movement relative to x, y, and z axes which are perpendicular to one another and which define a coordinate system for the three-dimensional space. Movement can involve translational and/or rotational movement relative to these axes; herein referred to as translational movement along the x, y, and z axes and rotational movement about

the x, y, and z axes. Accordingly, in three-dimensional space, there are six possible degrees freedom of motion, namely, translational motion along the x, y, and z axes, and rotational motion about the x, y and z axes. Movement in three-dimensional space, other than translational movement along and rotational about only one axis, involves simultaneous movement along a plurality of the x, y, and z axes. The present invention provides a joystick apparatus which functions as a user input device capable of indicating both movement and the magnitude of that movement. Moreover, the user input device is capable of movement simultaneously along a plurality of the axes x, y, and z.

The present invention provides a joystick apparatus having a control handle which can be moved in all directions so as to have six degrees freedom of motion corresponding to the six degrees freedom of motion of a three-dimensional object in three-dimensional space. Accordingly, the joystick apparatus of the present invention provides for user control and manipulation of objects and computer generated images in a very intuitive and interactive fashion. The joystick apparatus of the present invention can be readily interconnected to a computer system such that movement of the joystick apparatus directly corresponds to movement of the object and/or image being displayed on a display medium. That is, rotating the joystick will cause a similar rotation of the object or image and translational, also referred to as linear, movement of the joystick will cause a similar translational movement of the object or image. A feed-back loop may be present to provide a lag or lead time between movement of the joystick and the image or object. For example, in manipulating a three-dimensional image on a display medium, any desired view, orientation can be achieved by moving the control handle of the joystick as if

it were the image, since movement of the joystick directly corresponds to movement of the image. It will be appreciated that this facilitates and enhances user manipulation and orientation of objects and images.

One embodiment of the present invention preferably utilizes a plurality of one-dimensional sensors, also referred to as linear sensors, each capable of sensing one-dimensional translational movement along a straight line such as along one of the x, y, and z axes.

In some embodiments, rotational sensors are also used.

In yet other embodiments, in addition to sensing movement (direction and magnitude), the sensors can also be used to detect velocity and acceleration.

In the preferred embodiment, a plurality of joystick-type sensors each including sensors so as to be capable of sensing two-dimensional movement in a plane are utilized.

The sensors used by the joystick-type sensors might include a wide variety of sensor types such as force or motion transducers which will convert movement of the joystick apparatus central body into suitable electrical signals.

Linear motion sensors might include variable resistor sensors, optical sensors, switches, encoders, various digital sensors, etc.

In the preferred embodiment, the joystick apparatus is used with variable resistors or voltage output devices which will contain the information for the six degrees of movement. However, it will be appreciated that other types of one-dimensional sensors might be used, such as a digital sensor. A computer software interface will utilize the inputs from these variable resistors to control movement of the three-dimensional graphic images. It will be appreciated that the software interface required to

perform this task will be designed based on well known algorithms for controlling motion of three-dimensional images. Therefore, once given the benefit of the applicants' disclosure, the software interface algorithms are readily known to those of ordinary skill in the art.

In still other embodiments of the present invention, the input signals from the sensors will be used for controlling various types of input parameters such as calculating lag and/or lead times as well as varying the rate and/or acceleration of movement.

Although the preferred embodiment uses four (4) spaced apart, two-dimensional joystick apparatus, alternate embodiments might utilize three or more (e.g. five, six, etc.) two-dimensional joystick apparatus. The provision of additional two-dimensional joystick apparatus will provide redundancy of signals which allows for averaging of the joystick output signals. As few as two, three-axis, joystick apparatus might also be used. The multiple joystick configuration might provide increased support for the control handle of the joystick apparatus.

In one embodiment of the present invention, the control handle might be resiliently biased so as to return to a neutral position when released by the user. In other embodiments, the control handle will remain where it is placed.

The control handle of the present invention might take on any number of configurations such as an elongated member or a sphere. Indeed, a central body portion of the joystick might serve as the control handle.

In one embodiment of the present invention, a plurality of sensors radially disposed from a central body, are interconnected to the central body so as to detect translational and rotational movement of the central body in three-dimensional space and provide output signals representative of such movement.

These and various other advantages and features of novelty which characterize the present invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages and objects attained by its use, reference should be had to the drawings which form a further part hereof and to the accompanying descriptive matter and in which there is illustrated and described an embodiment of the invention.

Brief Description of the Drawings

In the drawings, in which like reference numerals indicate corresponding parts throughout the several views;

Figure 1 is a perspective view of an embodiment of a joystick apparatus in accordance with the principles of the present invention;

Figure 2 is a view similar to Figure 1 illustrating an embodiment of the present invention where only two three-dimensional joystick apparatus are present;

Figure 3 is a view of the embodiment shown in Figure 1 enclosed by a housing;

Figure 4 is a block diagram view of a computer graphics system wherein a joystick apparatus of the present invention might be utilized;

Figure 5 is a schematic top plan view of an embodiment of a joystick apparatus in accordance with the principles of the present invention;

Figure 6 is a side elevational view as seen generally along line 6-6 in Figure 5 of the embodiment illustrated in Figure 1;.

Figure 7 is an electrical diagram of a conventional two-dimensional joystick;

Figure 8 is a mechanical diagram of a conventional two-dimensional joystick;

Figure 9 is a view similar to Figure 1 of yet another embodiment of the present invention; and

Figure 10 is a cross-sectional diagrammatic view of the embodiment shown in Figure 9.

Detailed Description of a Preferred Embodiment

Referring now to Figure 1, 3 and 5-6, there is illustrated an embodiment of a user input device, hereafter referred to as a joystick apparatus, generally referred to by the reference numeral 20, in accordance with the principles of the present invention. The joystick apparatus 20 of the present invention provides for translational and rotational movement in any direction; i.e., six simultaneous degrees of freedom (motion) or, namely, simultaneous translational movement along x, y and z axes as generally illustrated by arrows 22, 24, 26, respectively, and simultaneous rotational movement about the x, y, and z axes as generally illustrated by the arrows 28, 30, 32, respectively. In the embodiment shown, the joystick apparatus has a range of rotation of roughly ±45° about the x, y and z axes, and has a range of translational motion of roughly ±1.5 inches or ±3.8 centimeters. For purposes of this description, movement is discussed in terms of x, y, and z axes perpendicular to one another which define a coordinate grid in three-dimensional space. As illustrated in Figure 1, the joystick apparatus is mounted on a support base 40. A central body portion 42 is interconnected to and supported by four conventional, two-dimensional joysticks 44 (also referred to as two-axis joysticks) each of which include linear sensors for sensing two-dimensional movement in a plane. Although, in alternate embodiments, as illustrated in Figure 2, wherein corresponding reference numerals are primed, the present invention might be implemented with only two joysticks 44'. In this embodiment, the joysticks 44' (also referred to as

three- axis joysticks) are capable of sensing rotational motion about a z-axis in addition to planar motion in the x-y plane. Typically, a twist knob is mounted on the handle of these joysticks. In yet other embodiments, three or any number of joysticks might be used.

The joysticks 44 include a base portion 45 and extensible (telescoping) handle members 46 which interconnect the base portion 45 of the joystick 44 to the central body portion 42. The handle members 46 are suitable interconnected to the base portions 45 of the joysticks 44 by a slider and ball joint arrangement 33 as illustrated in Figure 8 so as to provide for two degrees freedom of motion in a plane as is common in joysticks. In the embodiment shown, the joysticks 44 are fixedly supported above a surface of the support base by suitable support structure 43. The handle members 46 shown, include telescoping piston and cylinder portions 46a,b also referred to as telescoping tubing portions, so as to enable sliding motion therebetween. The cylinder portions 46b are interconnected to the central body portion 42 by a universal joint such as a ball joint 48. It will be appreciated that any number of u-joint arrangements might be used. For example, the cylinder portions 46b interconnected to the central body portion 42 by a flexible, resilient member. Also, the cylinder portions 46b might be disposed in an opening in the central body portion 42 having a greater diameter than the cylindrical portions 46b so as to allow movement of the central body portion 42. In the embodiment shown, the inner piece of each cylinder or tubing 46b has a ball mounted in a socket of the central body portion 42, such that the ball joints 48 are disposed about the central body portion in a common plane at ninety degree intervals. It will be appreciated that in alternate embodiments, the joysticks might not lie in the same plane. Indeed, they need not necessarily be

mutually orthogonal but must be non-coaxial or not all lined up along a common axis. In a preferred arrangement, the radius of the central body portion 42 is one-half the distance between a center of the central body portion 42 and the pivotal point of attachment of the handle members 46 to the base portions 45 of the joysticks 44.

As shown in Figure 3, the joystick apparatus 20 will preferably be enclosed by a housing 47 having an opening for projection therethrough of a control handle portion 60 interconnected to the central body portion 42, the opening allowing movement of the control handle portion 60 along the x, y, and z axes. In the embodiment shown, the opening is enclosed by flexible rubber-like layer 49 so as to allow movement of the handle 60 but enclose the inside of the joystick apparatus. The top of the housing 47 in this embodiment might serve as a place for resting the user's hand.

The movement of the central body portion 42 is sensed by variable resistors 50,52 associated with the four two-dimensional joysticks 44. It will be appreciated that other sensors might be used in keeping with the principles of the present invention. For example, various types of digital sensors might be used. Illustrated in Figure 7 is an electrical diagram 51 of a conventional two-dimensional joystick as might be used in the present invention, and illustrated in Figure 8 is a mechanical diagram of a conventional two-dimensional joystick 53 such as might be used in the present invention. In the embodiment shown, the variable resistor 52 on each of the two-dimensional joysticks 44 is influenced by vertical motion. With the appropriate electrical connections 56, each of the variable resistors 52 will output a higher voltage when the central body portion 42 is raised, and a lower voltage when the central body portion is lowered. If this is taken to be the z axis as discussed above, then x and y axis rotation

is also detected by these four resistors 52. In the case of rotation, about the x axis, one opposing pair 52a will not change while the other pair 52b will have one variable resistor 52b with a higher value and one variable resistor 52b with a lower value, depending on whether the rotation was in the positive or negative direction. When rotation is about the y-axis, the opposing pair of variable resistors 52a will change while the opposing pair 52b remains unchanged. The other four resistors 50 are also wired so that when the central body portion 52 slides along the y axis, the readings from two resistors 50a increase, while the other two resistors 50b are unaffected. The two resistors 50b are influenced by movement along the x axis, while the other two 50a are unaffected. The z axis rotation is detected by all four of the resistors 50a,b. In a preferred embodiment, the wiring scheme will be such that two of the resistors 50 will increase and two will decrease in voltage for positive rotation and vice versa for negative rotation. The resistors 50, 52 may be replaced with other variable impedance devices such as variable capacitors, etc. It will be appreciated that sensors other than variable impedance sensors may be utilized in keeping with the invention.

From these values, relative motion is detected by applying the proper algorithms to interpretation of the eight input values.

It will be appreciated that numerous alternative designs of the present invention, in keeping with the principles of the invention, might be utilized. For example, individual linear sensors disposed about the central body portion 42 might be used as opposed to two-dimensional joystick devices.

In the embodiment shown, the main handle portion 60 is interconnected to the central body portion for facilitating user manipulation of the central body portion.

It will be appreciated that the handle portion 60 might take on other configurations such as a sphere, etc. As illustrated in Figure 2, the handle might include a push button switch 61 for deactivating the joystick apparatus such that movement of the joystick does not affect the output from the joystick apparatus. For example, deactivation of the joystick apparatus would allow it to return to its neutral position without affecting its output.

As shown in Figure 2, an embodiment of the present invention might include a mechanism for biasing the control handle 60' back to a neutral position once the user releases the handle. In the embodiment shown, coiled springs 62 are so used to bias the control handle back to a neutral position. The central body portion 42' in this embodiment might be supported by a telescoping member 64.

Illustrated in Figures 9 and 10 is an alternate embodiment of the present invention (parts corresponding to those of Figure 1 being indicted by the same reference numerals, only double primed). In this embodiment, the joysticks 44'' are slidably mounted for linear movement on case bearing shafts 70, the shafts 70 being supported by a bracket 71. A mounting bracket 72 is attached to each of the joysticks 44'' and in turn mounted on the shafts 70 by use of suitable ball bushing mounts 74. It will be appreciated that any number of apparatus and methods might be used to slidably mount the joysticks 44''. In this embodiment, the central body portion 42'' is connected to the joysticks 44'' by a universal joint 76. In this embodiment, the handle members 46'' are not telescoping.

The joystick of the present invention has particular application for manipulation and control of three-dimensional computer generated images. Illustrated in Figure 4 is a block diagram of the joystick 20 of the present invention providing user input to a computer system

70 for controlling movement of computer generated images on a display medium 72. The computer system 70 might include controls for ignoring movement of the joystick apparatus such that joystick input can be selectively activated and deactivated. The present invention provides a very intuitive and interactive user input device for controlling computer generated three-dimensional images on a display medium. The present invention has numerous other applications such as robotics and avionics for controlling the movement of objects in three-dimensional space. For these and other applications, the computer system 70 might also include controls for achieving a desired amount of lead or lag of the object or image movement relative to the joystick. In addition, velocity and/or acceleration of the object or image might also be controlled in accordance with the joystick movement.

It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and function of various embodiments of the invention, this disclosure is illustrative only and changes may be made in detail, especially in matters of shape, size and arrangement of parts, within the principles of the present invention, to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

WHAT IS CLAIMED IS:

1. A joystick apparatus, comprising:

(a) central body means supported for translational and rotational movement in any direction within a limited three-dimensional space; and

(b) sensor means spaced apart from the central body means for sensing movement of the central body means.

2. An apparatus in accordance with claim 1, wherein the joystick apparatus includes a plurality of the sensor means disposed about and spaced from the central body means for sensing motion of the central body means in the three-dimensional space.

3. An apparatus in accordance with claim 2, wherein the sensor means are slidably mounted, the central body means being interconnected to the sensor means by universal joint means for enabling universal movement of the central body means relative to the sensor means.

4. An apparatus in accordance with claim 2, wherein the sensor means includes at least three, two-dimensional joystick apparatus.

5. An apparatus in accordance with claim 2, wherein the sensor means include rotational motion sensors, at least two of the rotational sensors cooperating to sense translational motion of the central body means.

6. An apparatus in accordance with claim 2, wherein the sensor means include at least three translational motion sensors.

7. An apparatus in accordance with claim 1, including transducer means for converting the sensed

movement of the central body means into electrical signals representative of the sensed movement.

8. An apparatus in accordance with claim 2, wherein the sensor means include at least three two-dimensional force sensors.

9. An apparatus in accordance with claim 2, wherein the sensor means are disposed in a common plane.

10. A computer graphics input device used for controlling movement of an image on a computer graphics display terminal, the input device comprising:

(a) body means supported for translational and rotational movement in any direction within a limited three- dimensional space; and

(b) transducer means for sensing movement of the body means and converting the sensed movement into output signals for input to the computer graphics display terminal.

11. A joystick apparatus, comprising:

(a) a central body portion being supported by support means for translational and rotational movement in any direction within a predefined limited three-dimensional space; and

(b) a plurality of sensor means suitably interconnected thereto for sensing translational motion, two or more of the sensor means cooperating to sense rotational motion.

12. A joystick apparatus in accordance with claim 11, wherein the sensor means are radially removed from and disposed about the central body portion in a common plane.

13. A joystick apparatus in accordance with claim 12, wherein the sensor means are disposed about the central body portion at substantially one hundred twenty degree intervals.

14. A joystick apparatus in accordance with claim 11, wherein the sensor means include a plurality of linear sensors each capable of sensing one-dimensional movement.

15. A joystick apparatus in accordance with claim 13, wherein cooperating pairs of the linear sensors form two-dimensional sensor means disposed about the central body portion.

16. A joystick apparatus, comprising:

(a) a support base;

(b) a central body portion;

(c) at least three, two-dimensional joystick apparatus each having a base portion and control handle means interconnected to the base portion so as to have two degrees of motion, the two-dimensional joystick apparatus including sensor means for sensing movement of the control handle means relative to the base portion and for providing output signals representative of such movement, the control handle means of the two-dimensional joystick apparatus being interconnected to the central body portion by universal joint means for universal movement relative to the central body portion, adjustable length means cooperating with the handle means for providing variable displacement between the central body portion and the base portions of the two-dimensional joystick apparatus, whereby the central body portion can be moved in all directions so as to be provided with six degrees of motion, namely, translational motion along the x, y and z axes and rotational motion about the x, y and z axes; and

(d) main control handle means extending from the central body portion for facilitating user manipulation of the central body portion.

17. An apparatus in accordance with claim 16, wherein the universal joint means are disposed about the central body portion at predetermined locations.

18. An apparatus in accordance with claim 16, wherein the universal joint means are disposed about the central body portion in a common plane at ninety degree intervals.

19. An apparatus in accordance with claim 16, wherein the u-joint means comprises ball joint means.

20. An apparatus in accordance with claim 16, wherein the adjustable length means includes a plurality of telescoping members.

21. An apparatus in accordance with claim 16, wherein the adjustable length means comprises first and second members slidably interconnected.

22. An apparatus in accordance with claim 16, wherein the sensor means of the two-dimensional joystick means comprises variable impedance devices.

23. An apparatus in accordance with claim 16, wherein there are four two-dimensional joystick apparatus present.

24. An apparatus in accordance with claim 16, further including means for resiliently biasing the central body portion toward a neutral position.

25. An apparatus in accordance with claim 16, wherein each of the two-dimensional joystick means includes first and second variable impedance means, the first variable impedance means on each of the two-dimensional joystick means being influenced by z axis motion of their respective control handle means, whereby z axis translational motion of the central body portion is detected as well as x and y axis rotational motion of the central body portion, a first opposing pair of the second variable impedance means on the two-dimensional joystick means being influenced by x axis translational movement and a second opposing pair of the second variable impedance means on the two-dimensional joystick means being influenced by y axis translational movement, said second variable impedance means further being influenced by z axis rotational movement, whereby z axis rotational movement of the central body portion as well as x and y axis movement of the central body portion is detected.

26. A computer graphics system, comprising:

(a) a display medium;

(b) a computer system for generating three-dimensional computer images on the display medium; and

(c) a joystick apparatus having six degrees of motion, namely, translational motion along x, y and z axes and rotational motion about x, y and z axes, providing input to the computer system for user manipulation and control of the three-dimensional image displayed on the display medium by the computer system.

27. A computer graphics system in accordance with claim 26, wherein movement of the joystick apparatus corresponds to movement of the three-dimensional image displayed on the display medium by the computer system.

28. A computer graphics system in accordance with claim 27, wherein the joystick apparatus includes linear sensor means for providing the input to the computer system.

29. A method for manipulation and orientation of objects whether they be physical objects or images on a display media; the method comprising the steps of:

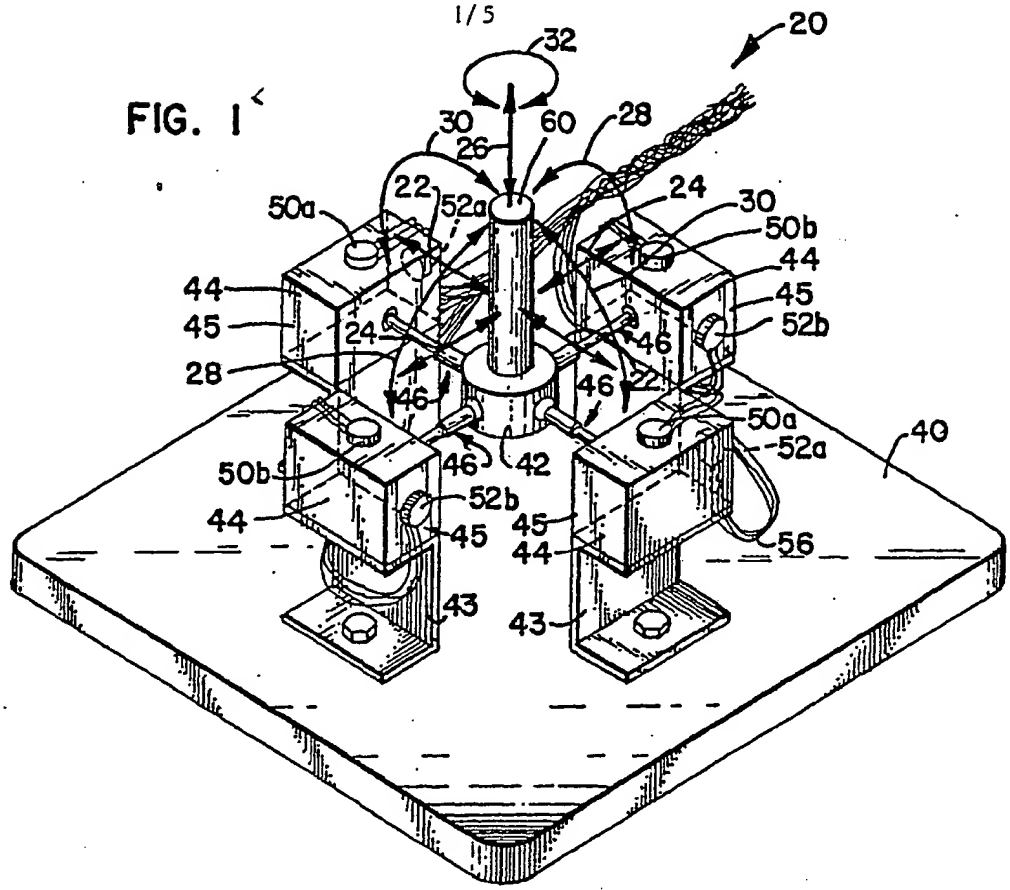
(a) manipulating and orientating control handle means in any direction and orientation desired in three-dimensional space;

(b) sensing movement of the control handle means by use of a plurality of sensor means;

(c) outputting signals representative of the movement of the central handle means as sensed by the sensor means; and

(d) manipulating and orientating the object corresponding to the movement of the control handle means.

FIG. 1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32
60
30
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28
22
52a
24
30
50a
50b
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45
52b
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28
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52a
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52b
56
43

FIG. 4

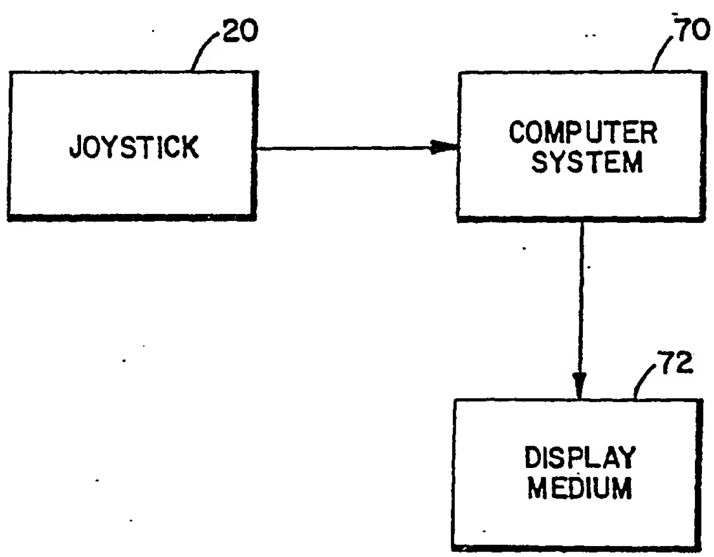

20
JOYSTICK
70
COMPUTER SYSTEM
72
DISPLAY MEDIUM

FIG. 2

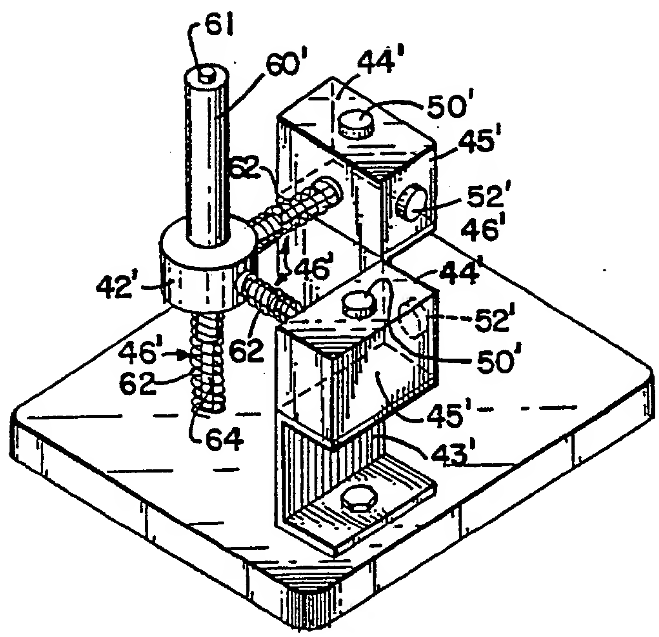


FIG. 3

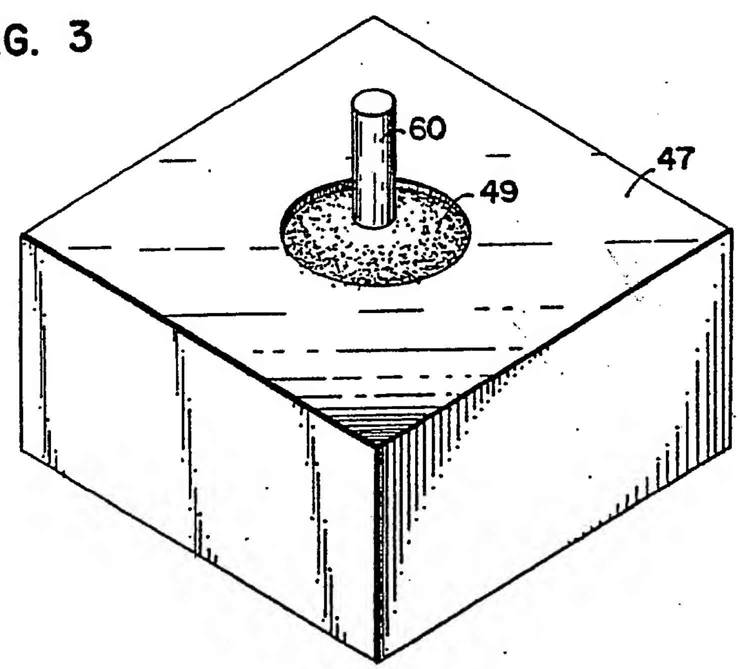
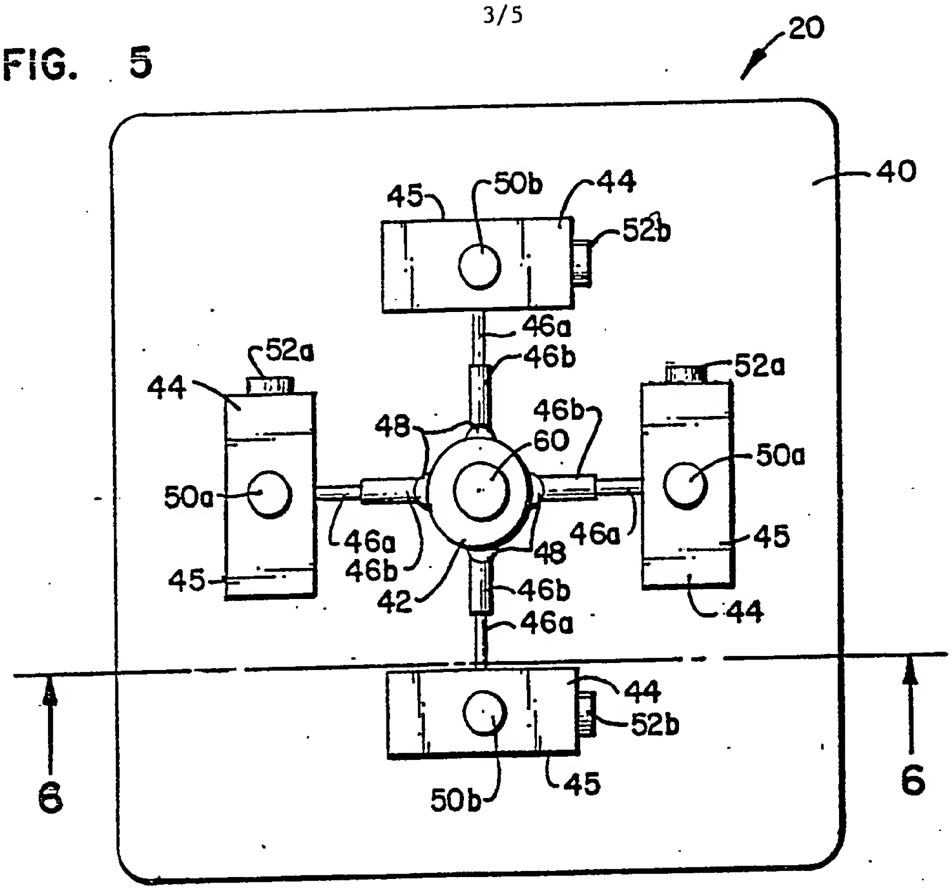


FIG. 5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52b
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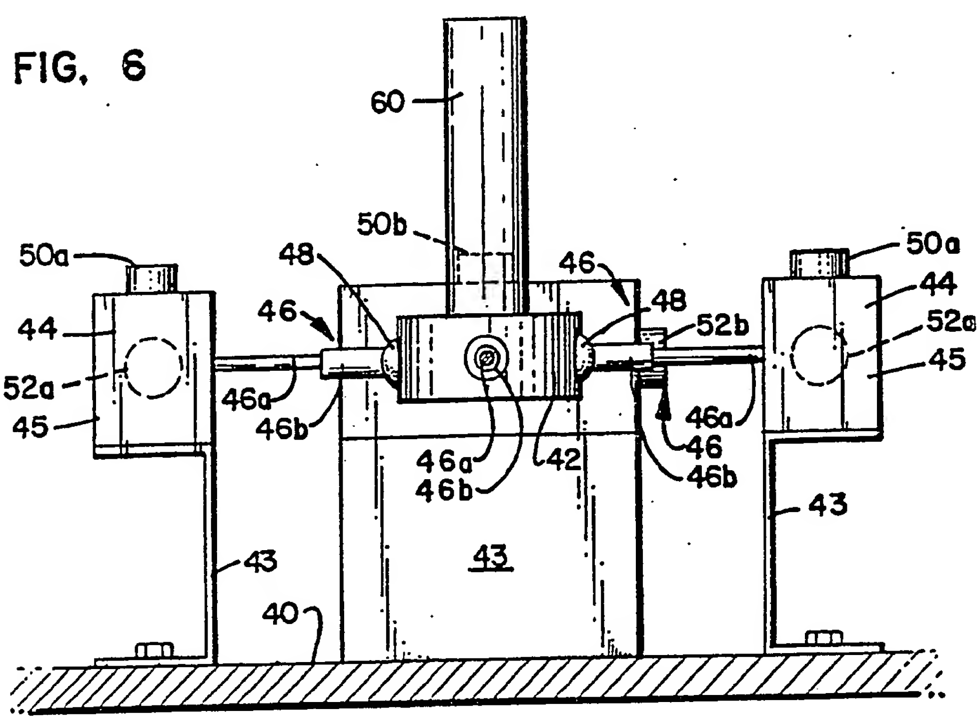
6
50b
45

FIG. 6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46
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46b
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46b
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43
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FIG. 7

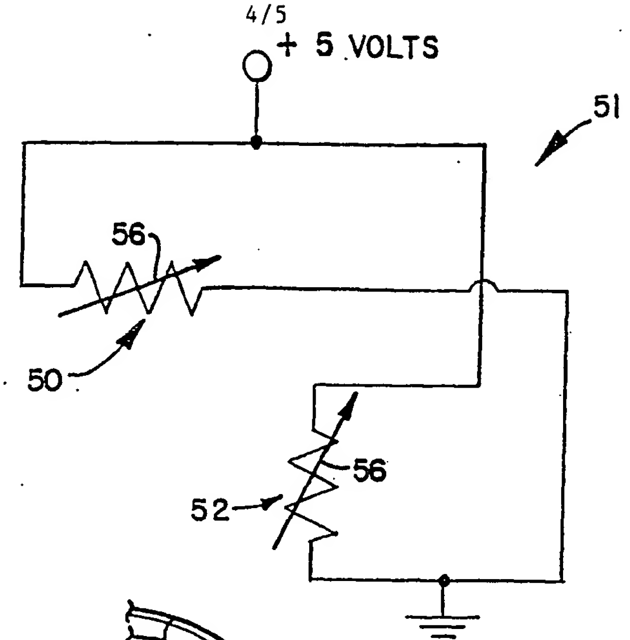


FIG. 8

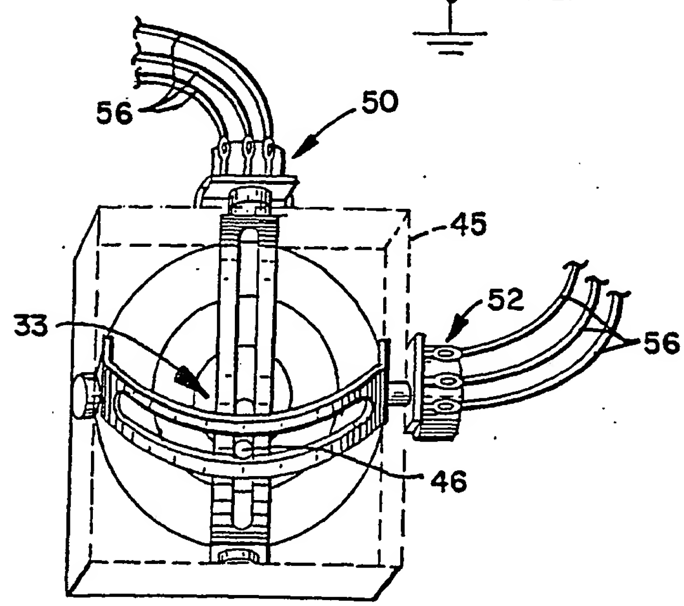
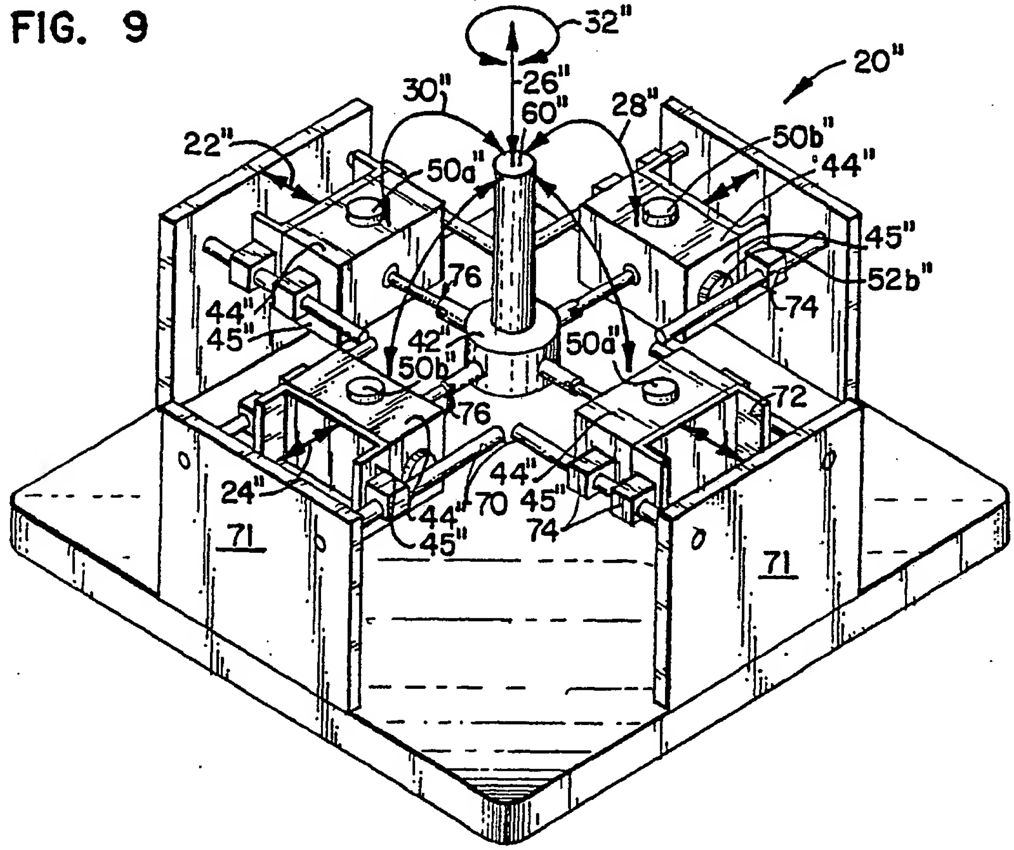


FIG. 9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76
74
44"
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50b"
72
76
44"
24"
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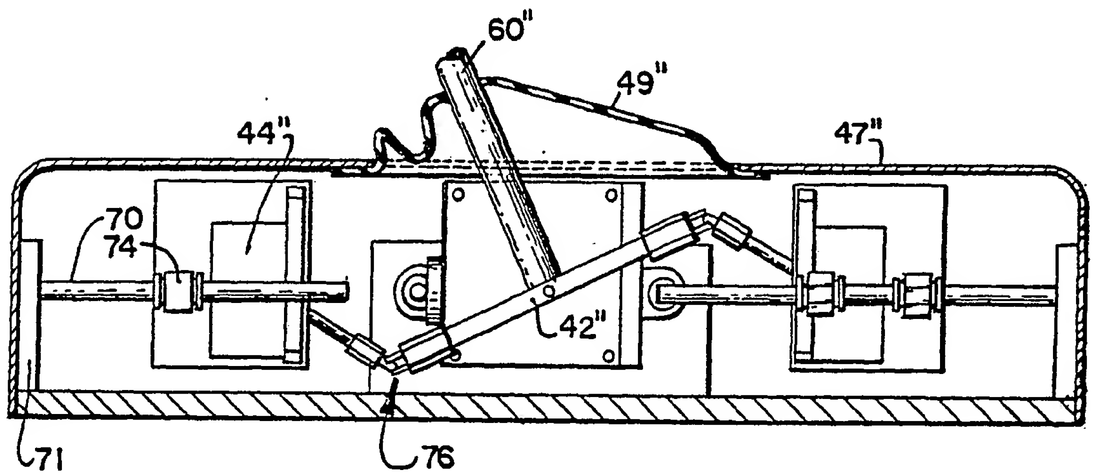
44"
70
74
45"
71
71

FIG. 10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44"
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70
74
42"
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76

INTERNATIONAL SEARCH REPORT

International Application No PCT/US88/00291

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4) G06F 3/033
U.S. cl. 340/709

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	340/709, 365R, 365S, 365L; 358/22 273/148B; 74/471XY; 250/221

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	U.S. A, 4,468,688 (GABRIEL ET AL) 28 August 1984. See columns 33 and 34.	1-29
Y	U.S. A, 4,161,726 (BURSON ET AL) 17 July 1979. See columns 1 and 2.	3, 16, 17, 18, 19, 20, 21, 22, 23, 24
Y	U.S. A, 3,350,956 (MONGE) 07 November 1967. See the entire document.	1-29
Y	Ciarcia (Joystick Interfaces Publication) BYTE Publication Inc.; Pages 10-18; September 1979; See the entire document.	2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 23, 25
A	Carmichael (Joystick Resolving Mechanism) IBM Technical Disclosure Bulletin; Vol. 21 No. 12 May 1979; Pages 5023-5024.	
A	AHL (Controller Update) Creative Computing December 1983; Pages 142-154.	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
26 April 1988	27 MAY 1988
International Searching Authority [1]	**Signature of Authorized Officer** [10]
ISA/US	Mahmoud Fatahi-yar Mahmoud Fatahi-yar

International Application No. PCT/US88/00291

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
A	U.S. A, 4,216,467 (COLSTON) 05 August 1980.	

Form PCT/ISA/210 (extra sheet) (May 1986)

NAA00014774

Look-up in JPO

(19)日本国特許庁（JP）　(12) 公開実用新案公報（U）　(11)実用新案出願公開番号

実開平5−87760

(43)公開日　平成5年(1993)11月26日

(51)Int.Cl.⁵	識別記号	庁内整理番号	FI	技術表示箇所
H01H 13/00	C	7250−5G		
13/52	E	4235−5G		

審査請求　未請求　請求項の数1（全 2 頁）

(21)出願番号　実願平4−26276

(22)出願日　平成4年(1992)4月22日

(71)出願人　000006220
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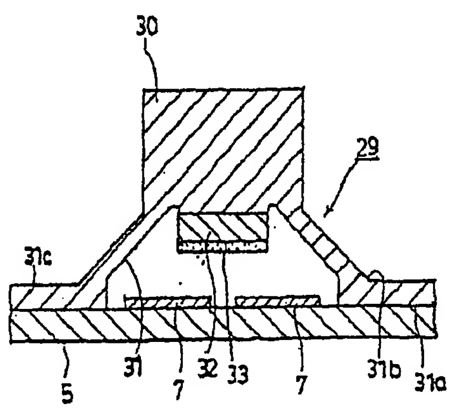
東京都調布市国領町2丁目13番地19号　早勝荘9号室

(74)代理人　弁理士　林　孝吉

(54)【考案の名称】　感圧スイッチ

(57)【要約】
【目的】　スイッチ操作時に於て、操作者の意思によって、例えばビデオゲームのキャラクターの動作を自由にコントロールできるようにする。
【構成】　可動部30の下面に可動接点32が設けられているラバー接点29であって、該可動接点32の下面に押し圧によって抵抗値が変化する導電部33を装着する。



【実用新案登録請求の範囲】

【請求項1】　可動部の下面に可動接点が形成されたラバー接点に於て、該可動接点の下面に押し圧により抵抗値が変化する導電部を装着して成る感圧スイッチ。

【図面の簡単な説明】

【図1】本考案を実施したビデオゲーム用のコントローラの平面図。

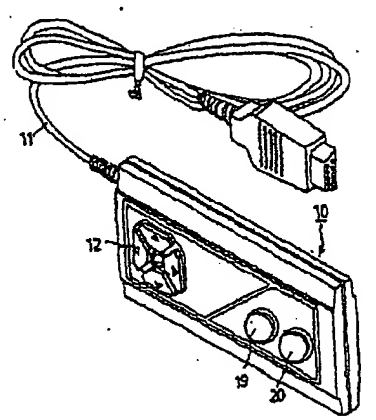
【図2】本考案の要部の縦断正面図、

【図3】従来型の縦断正面図。

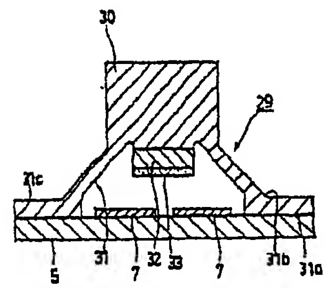
【符号の説明】

5	基板
7	固定接点
29	ラバー接点
30	可動部
31	弾性脚部
32	可動接点
33	押し圧によって抵抗値が変化する導電部

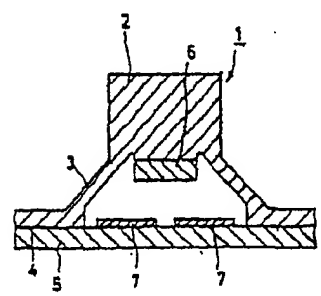
【図1】



【図2】



【図3】



【考案の詳細な説明】

【0001】

【産業上の利用分野】

本考案は、感圧スイッチに関するものであり、特に、ラバー接点の可動部の押し圧力を変化させることによって電気的抵抗値を変化できるようにした感圧スイッチに関するものである。

【0002】

【従来の技術】

従来の此種ラバー接点を図3に従って説明する。図3は該ラバー接点の断面図である。図に於てラバー接点1の可動部2の外周から弾性脚部3が斜め下方へ斜設され、そして、該弾性脚部3の下端部から水平方向へ延設されて水平部4とし、該水平部4を基板5上に載置せしめる。又、該可動部2の下端部には導電性ゴム等にて可動接点6が夫々形成されており、且つ、該可動接点6の下端面は、可動部2を打鍵しないときには前記弾性脚部3の下端部より上方へ位置し、該可動部2の上面を下圧することにより、弾性脚部3の弾性的付勢に抗し、前記可動接点6が下降して基板5に配設されている配線パターンの固定接点7，7にオンすることになる。

【0003】

更に、該可動部2の前記打鍵を解除すれば、可動部2は弾性脚部3の弾性復元力により上動し、前記接点相互のオン状態が解除されることになる。

【0004】

【考案が解決しようとする課題】

上記従来型のラバー接点1は可動部2を打鍵すれば、該可動部2の下面に設けられている導電部である可動接点6が基板5に配設されている配線パターンの固定接点7，7にオンする。そして、該打鍵操作を解除することにより前記相互の電気的結合が解除される。従って、該ラバー接点1は単に電気的オン・オフの操作を為すだけであって、例えば、ビデオゲーム等のキャラクターの動作を操作者の意志で自由にコントロールすることはできない。

【0005】

そこで、スイッチ操作時に於て、操作者の意思により、例えばビデオゲームのキャラクターの動作を自由にコントロールできるようにするために解決せらるべき技術的課題が生じてくるのであり、本考案は該課題を解決することを目的とする。

【0006】

【課題を解決するための手段】

本考案は上記目的を達成するために提案せられたものであり、可動部の下面に可動接点が形成されたラバー接点に於て、該可動接点の下面に押し圧により抵抗値が変化する導電部を装着して成る感圧スイッチを提供するものである。

【0007】

【作用】

本考案は可動部の下面に形成されている導電部である可動接点の下面に更に押し圧によって電気的抵抗値が変化する導電部を装着しているので、例えば、本考案のスイッチをビデオゲームのコントローラ用として用いているときには、操作者が本考案のスイッチの可動部を押圧する際、その押圧力の程度によって可動接点の下面に装着している前記導電部の電気的抵抗値が変化し、依って、該抵抗変化値がコントローラ信号の変化をうながす。斯くして、前記ビデオゲームのキャラクターの動作が操作者の意思により自由にコントロールされる。

【0008】

【実施例】

以下、本考案の一実施例を図1及び図2に従って詳述する。尚、説明の都合上、従来公知に属する構成も同時に説明し、対象部分は同一符号を用いるものとする。図1はコントローラ10を示し、ケーブル11を介してビデオゲーム機（図示せず）に接続される。コントローラ10の上面左の＋字キー12は、画面上のキャラクターを上下左右に移動させるものである。右側の19、20はトリガーキーである。

【0009】

図2は前記コントローラ10に設けられている＋字キー12のラバー接点29の縦断正面図である。尚、この実施例では＋字キー12のラバー接点について説

明しているが之に限定せらるべきではない。該ラバー接点29は従来例にて説明したように弾性ゴム材より成り、前記十字キー12の夫々の中心部に可動部30が設けられ、各可動部30は夫々の外周中間部より弾性脚部31が斜め下方に斜設され、該弾性脚部31の下端面31aが基板5の上面に載置される。又、前記各可動部30の下端部には導電性ゴムにて夫々可動接点32が配設され、且つ、該可動接点32の下端面には、押し圧によって抵抗値が変化する導電部33が夫々印刷又は一体成形にて装着されている。そして該可動部30を押圧（打鍵操作）しない状態では、前記弾性脚部31の下端面31aより上方へ位置し、打鍵操作によって該可動部30は弾性脚部31の弾性付勢力に抗して下降し、基板5に設けた配線パターンの各固定接点7，7に電気的結合が為されるようになっている。そして、前記押圧動作を解除することにより、該可動部30が弾性脚部31の弾性復元力にて上動し、前記電気的結合が解除される。

【0010】

而して、該ラバー接点29の夫々の可動部30は夫々前記十字キー12の各先端部に設けた押圧部（各△印）の下部に対応して設けられており、該十字キー12の押圧部を指頭にて押圧することにより、該押圧部の方向にビデオゲームのキャラクターが移動し、而も、、該指頭による押圧力の大小によって該キャラクターの移動速度が変化する。即ち、前記十字キー12の各押圧部に対する指頭による押圧力はラバー接点29の可動部30の下面に装着されている押し圧によって抵抗値が変化する導電部33によって電気抵抗が変化する。斯くして、ビデオゲームのキャラクターの動作が前記操作者の指頭による押圧力によって任意にコントロールすることができる。

【0011】

而して、上記一実施例はビデオゲームのコントローラ10に実施した場合を説明したが、その他、マルチバイブレーターの抵抗部に本考案のスイッチを用いることにより、周波数をスイッチの押し圧によって変化させることもできる。　尚、この考案は、この考案の精神を逸脱しない限り種々の改変を為すことができ、そして、この考案が該改変されたものに及ぶことは当然である。

【0012】

【考案の効果】

この考案は、上記一実施例に詳述せる如く、スイッチの可動部を押圧してスイッチング動作を為すとき、該押圧力を変化させることによってスイッチの電気的抵抗値が変化し、依って、例えばビデオゲームのキャラクターの動作をスイッチの押圧力によって自由にコントロールすることができることになり、操作者の意思が直接に該キャラクターの動作に表現される。斯くして、該ビデオゲーム等に対する興味を一層助成する等、正に著大なる効果を奏する考案である。

(12) Japanese Unexamined Utility Model Application Publication

(11) Publication No. 5-87760

(43) Publication Date: November 26, 1993

(21) Application No. 4-26276

(22) Application Date: April 22, 1992

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(74) Agent: Patent Attorney, Yoshitaka HAYASHI

(54) [Title of the Invention] PRESSURE-SENSING SWITCH

(57) [Abstract]

[Object] To enable an operator to freely control, for example, the operation of a character of a video game, when performing a switching operation.

[Construction] In a rubber contact 29 in which a moving contact 32 is disposed on the bottom surface of a moving part 30, a conductive portion 33 whose resistance varies with a pressing force is attached to the bottom surface of the moving contact 32.

[Claim]

[Claim 1] A pressure-sensing switch comprising a rubber contact in which a moving contact is formed at a bottom surface of a moving part, wherein a conductive portion whose resistance changes with a pressing force is attached to a bottom surface of said moving contact.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a perspective view illustrating a controller for use in a video game, which embodies the present invention.

[Fig. 2] Fig. 2 is a longitudinal sectional front view illustrating the essential portion of the present invention.

[Fig. 3] Fig. 3 is a longitudinal sectional front view illustrating a conventional type.

[Reference Numerals]

5 substrate

7 fixed contact

29 rubber contact

30 moving part

31 elastic leg portion

32 moving contact

33 conductive portion whose resistance varies with a pressing force

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

The present invention relates to a <u>pressure-sensing</u> switch and, more particularly, to a pressure-sensing switch in which electrical resistance is made variable by changing the pressure on a moving part of a rubber contact.

[0002]

[Description of the Related Art]

A conventional rubber contact of this type is discussed below with reference to Fig. 3. Fig. 3 is a sectional view illustrating the rubber contact. In Fig. 3, an elastic leg portion 3 obliquely slopes downward from the peripheral portion of a moving part 2 of a rubber contact 1, and a horizontal portion 4 which horizontally extends from the bottom of the elastic leg portion 3 is placed on a substrate 5. At the bottom of the moving part 2, a moving contact 6, such as conductive rubber, is formed. When the moving part 2 is not pressed, the bottom surface of the moving contact 6 is positioned above the bottom of the elastic leg portion 3. By pressing the top surface of the moving part 2 downward, the moving part 6 is lowered while being resisted by <u>an elastic urging force</u> of the elastic leg portion 3 so as to connect fixed contacts 7, 7 of a wiring pattern disposed on the substrate 5.

physical resistance (like a dome cap)

[0003]

By stopping the releasing operation on the moving part 2, the moving part 2 is lifted by an elastic restoring force of the elastic leg portion 3 so as to disconnect the above-described contacts.

[0004]

[Problems to be Solved by the Invention]

According to the aforementioned conventional rubber contact 1, by pressing the moving part 2, the moving contact 6, which is a conductive portion, disposed on the bottom surface of the moving part 2 connects the fixed contacts 7, 7 of the wiring pattern disposed on the substrate 5. Then, by discontinuing the pressing operation, the above-described electrical connection is released. Thus, the rubber contact 1 merely effects an electrical on/off operation, and does not enable the operator to freely control, for example, the operation of a character in a video game.

[0005]

Accordingly, there is a technical problem to be solved, so that the operator is able to freely control, for example, the operation of a character in a video game by operating the switch. It is an object of the present invention to solve the above-described problem.

[0006]

[Means for Solving the Problems]

In order to achieve the above object, according to the present invention, there is provided a pressure-sensing switch comprising a rubber contact in which a moving contact is formed at a bottom surface of a moving part, wherein a conductive portion whose resistance changes with a pressing force is attached to a bottom surface of the moving contact.

[0007]

[Operation]

In the present invention, a conductive portion whose electrical resistance changes with a pressing force is fixed on the bottom surface of the moving contact, which is also a conductive portion, formed on the bottom surface of the moving part. Accordingly, when using the switch of the present invention as, for example, a controller of a video game, when the operator presses the moving part of the switch, the electrical resistance of the conductive portion fixed on the bottom surface of the moving contact changes according to the degree of the pressing force, thereby changing a signal from the controller. This enables the operator to freely control the operation of the character of the video game.

[0008]

[Embodiment]

An embodiment of the present invention is described in detail below with reference to Figs. 1 and 2. While

describing the present invention, the construction of the related art is simultaneously discussed, and counterpart components are designated with like reference numerals. Fig. 1 illustrates a controller 10, which is connected to a video game machine (not shown) via a cable 11. A cross key 12 positioned at the upper left portion of the controller 10 is used for vertically and horizontally moving characters on the screen. Reference numerals 19 and 20 shown at the right portion indicate trigger keys.

[0009]

Fig. 2 is a longitudinal sectional front view illustrating a rubber contact 29 of the cross key 12 provided for the controller 10. Although in this embodiment the rubber contact of the cross key 12 is discussed, the present invention is not restricted to this. As discussed in the description of the related art, the rubber contact 29 is formed of an elastic rubber material, and a moving part 30 is disposed at the central portion of each section of the cross key 12. An elastic leg portion 31 slopes obliquely downward from the peripheral middle portion of each moving part 30, and a bottom surface 31a of the elastic leg portion 31 is placed on the top surface of the substrate 5. A moving contact 32, which is formed of conductive rubber, is disposed at the bottom end of each moving part 30, and a conductive portion 33 whose resistance varies with pressure

is attached to the bottom end surface of the moving contact 32 by printing or integral molding. When the moving part 30 is not pressed (when the pressing operation is not performed), the conductive portion 33 is positioned above the bottom end surface 31a of the elastic leg portion 31. By performing the pressing operation, the moving part 30 is lowered while being resisted by an elastic urging force of the elastic leg portion 31 so that it is electrically connected to the fixed contacts 7, 7 of a wiring pattern disposed on the substrate 5. By discontinuing the pressing operation, the moving part 30 is lifted by an elastic restoring force of the elastic leg portion 31, thereby releasing the above-described electrical connection.

[0010]

The moving part 30 of the rubber contact 29 is provided at the bottom of the pressing portion (indicated by Δ) provided for each forward end of the cross key 12. By pressing the pressing portion of the cross key 12 with a fingertip, the character of the video game is moved in the direction corresponding to the pressed portion, and the speed of the character's movement changes according to the magnitude of the pressing force applied by a fingertip. That is, the pressing force applied by the fingertip on each pressing portion of the cross key 12 changes the electrical resistance through the conductive portion 33, whose

resistance changes according to the pressing force, fixed on the bottom surface of the moving part 30 of the rubber contact 29. Thus, the operation of the character of the video game can be freely controlled by the pressing force applied by the fingertip of the operator.

[0011]

In the foregoing embodiment, the present invention is used in the controller 10 of a video game. However, the switch of the present invention may be used for a resistor of a multi-vibrator so as to change the frequency by the pressing force on the switch. It should be noted that various modifications may be made to the present invention within the spirit of the invention, and the present invention encompasses such modifications.

[0012]

[Advantages]

As is seen from the detailed description of the above-described embodiment, the present invention offers the following enormous advantages. In performing the switching operation by pressing the moving part of the switch, the electrical resistance of the switch varies by changing the pressing force. ~~This makes it possible to freely control, for example, the operation of a character of a video game, by the pressing force on the switch, and thus, the operator's intention can be directly reflected on the~~

~~operation of the character~~ Hence, according to the present invention, the entertaining characteristics of, for example, the video game can be considerably increased.

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25401, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as

Laid Open Utility Model H5-87760
"Pressure Sensing Switch"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

Roger P. Lewis

ROGER P. LEWIS

January 30, 2007

[redacted]

公開実用 昭和61-103836

⑲日本国特許庁(JP)　⑪実用新案出願公開

⑫公開実用新案公報(U)　昭61-103836

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H 01 H 13/52		Z-7337-5G	
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㊹考案の名称　可変抵抗スイッチ

㉑実願 昭59-188849

㉒出願 昭59(1984)12月14日

⑫考案者	松本 和博	藤沢市本町4-3-22
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⑭代理人	弁理士 小川 信一	外2名

明細書

1．考案の名称

可変抵抗スイッチ

2．実用新案登録請求の範囲

ケース底部に設けられた二対の電極と、ケース内でそのうちの一対の電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないように一端がケースに、他端が残りの一対の電極のうちの一方の端部に支持され、押圧により曲率中心を通る法線方向が直角方向に変化する弾性導電曲面板と、この曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンとからなる可変抵抗スイッチ。

3．考案の詳細な説明

〔産業上の利用分野〕

本考案はスイッチのオン、オフ機能の切換動作を指先の押圧感覚で容易に判断することができると共に、スイッチの押しボタンの押し具合で2つの端子間の抵抗値を変化させることがで

[redacted] [redacted]

きる可変抵抗スイッチに関する。

〔従来の技術〕

従来の感圧素子、特に感圧導電性ゴムを使用した可変抵抗スイッチは、スイッチケースの底部に一対の電極が敷設され、その上に載置された感圧導電性ゴムの上面を押しボタンで押圧することによる感圧導電性ゴムの抵抗値の変化を利用するのが一般的である。

ところが、このような可変抵抗スイッチについては、オフ状態で押しボタンを押した時に、オフ状態から可変抵抗機能を働かせるまでの動作中に、いつオン状態となったかの切換節度（クリックアクション）がなく、押しボタンの操作者にとってこのスイッチが使いづらいものとなることが多かった。

〔考案の目的〕

本考案の目的は前記従来の可変抵抗スイッチの有する欠点を解消し、押圧操作時にオフ状態からオン状態に切り換わったことが操作者に明確に判断できるように、押しボタンのストロー

クの途中に切換点（クリックポイント）を持たせ、さらに押しボタンを押し続けると2つの端子間の抵抗値を変化させることができる優れた可変抵抗スイッチを提供することである。

〔考案の構成〕

前記目的を達成する本考案の可変抵抗スイッチは、ケース底部に設けられた二対の電極と、ケース内でそのうちの一対の電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないように一端がケースに、他端が残りの一対の電極のうちの一方の端部に支持され、押圧により曲率中心を通る母線方向が直角方向に変化する弾性導電曲面板と、この曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンとを備えていることを特徴としている。

〔実施例〕

以下添付図面を用いて本考案の実施例を説明する。

第1図〜第4図はそれぞれ本考案の可変抵抗

スイッチ10の一実施例の構造を示す平断面図、底面図、互いに直交する方向の縦断面図である。

この実施例の可変抵抗スイッチ10は、下部スイッチケース2Bと、これを覆う上部スイッチケース2Aと、この上部スイッチケース2Aの上側に露出する押しボタン1とを備えている。そして、前記下部スイッチケース2Bの底部には、二対の電極4A,4B，5A,5Bがそれぞれ所定の間隙を隔てて敷設されており、これらの電極4A,4B，5A,5Bの端部はそれぞれ端子4C,4D，5C,5Dによって下部スイッチケース2Bの底部外に突出している。

これらの電極のうち、一対の電極5A，5Bの上には、これら両電極5A，5Bに跨るように均一厚の平板状感圧導電性ゴム6が載置されており、この感圧導電性ゴム6の上部にはこれを覆うようにブリッジ電極7が設けられている。このブリッジ電極7は、導電層7Aと絶縁層7Bとから構成されており、前記感圧導電性ゴム6側が導電層7Aとなっているが、前記感圧導電性ゴム6は加圧されない限り導電性を示さず、圧力に応じ

⑲日本国特許庁（JP）　⑪実用新案出願公開

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⑫考　案　者　金　子　　理　人　平塚市南原1−28−1

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⑪出　願　人　横浜ゴム株式会社　東京都港区新橋5丁目36番11号

⑭代　理　人　弁理士　小川　信一　外2名

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（産業上の利用分野）

本考案はスイッチのオン、オフ機能の切換動作を指先の押圧感覚で容易に判断することができると共に、スイッチの押しボタンの押し具合で2つの端子間の抵抗値を変化させることがで

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ところが、このような可変抵抗スイッチについては、オン状態で押しボタンを押した時に、オフ状態から可変抵抗機能を働かせるまでの動作中に、いつオン状態となったかの切換節度（クリックアクション）がなく、押しボタンの操作者にとってこのスイッチが使いづらいものとなることが多かった。

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本考案の目的は前記従来の可変抵抗スイッチの有する欠点を解消し、押圧操作時にオフ状態からオン状態に切り換わったことが操作者に明確に判断できるように、押しボタンのストロー

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前記目的を達成する本考案の可変抵抗スイッチは、ケース底部に設けられた二対の電極と、ケース内でそのうちの一対の電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないように一端がケースに、他端が残りの一対の電極のうちの一方の端部に支持され、押圧により曲率中心を通る母線方向が直角方向に変化する弾性導電曲面板と、この曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンとを備えていることを特徴としている。

〔実施例〕

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この実施例の可変抵抗スイッチ10は、下部スイッチケース2Bと、これを覆う上部スイッチケース2Aと、この上部スイッチケース2Aの上側に露出する押しボタン1とを備えている。そして、前記下部スイッチケース2Bの底部には、二対の電極4A,4B, 5A,5Bがそれぞれ所定の間隙を隔てて敷設されており、これらの電極4A,4B, 5A,5Bの端部はそれぞれ端子4C,4D, 5C,5Dによって下部スイッチケース2Bの底部外に突出している。

これらの電極のうち、一対の電極5A, 5Bの上には、これら両電極5A, 5Bに跨るように均一厚の平板状感圧導電性ゴム6が載置されており、この感圧導電性ゴム6の上部にはこれを覆うようにブリッジ電極7が設けられている。このブリッジ電極7は、導電層7Aと絶縁層7Bとから構成されており、前記感圧導電性ゴム6側が導電層7Aとなっているが、前記感圧導電性ゴム6は加圧されない限り導電性を示さず、圧力に応じ

て抵抗値が変化するので、無負荷状態では前記電極5A，5Bは絶縁状態に保持されている。

そして、前記ブリッジ電極7の上方には弾性導電曲面板3が、その一端をケース内の段部2Cに支持され、他端が前記一対の電極4A，4Bのうちの一方の電極、例えば電極4Aに支持され、ブリッジ電極7に非接触状態で位置している。この弾性導電曲面板3は、第5図に示すようにその長手方向両端部が上方に湾曲して凹面が上を向いた形状をしており、その曲率中心を通る母線8の一端が前述のように下部スイッチケース2Bの側面に形成された段部2Cに載置状態で支持され、他端が電極4Aに支持されている。前記電極4Aに対になる段部2C側の電極4Bは、前記段部2Cよりも低く形成されており、さらに前記ブリッジ電極7の上面はこの電極4Bよりも低い位置にある。このために、前記弾性導電曲面板3は電極4Bおよびブリッジ電極7に非接触の状態にあるのである。

前記弾性導電曲面板3は、例えばばね性を有

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する80μ程度のリン青銅で形成されており、凹面側から矢印Fで示す力で母線8の中心を押圧した場合、この凹面は弾性変形を起こし、クリックアクションで前記凹面の向きが変化し、母線8の方向は第6図に母線9で示すように直角方向に変化する。

この時、前記弾性導電曲面板3の底面3Aが前記電極4Bに接触するように、電極4Bと下部スイッチケース2Bの段部2Cとの距離が調整されている。そして、さらに押圧されると弾性導電曲面板3は下方に湾曲し、前記ブリッジ電極7に接触しながらこれを押圧することになる。

また、この実施例では弾性導電曲面板3は長手方向両端部が上方に湾曲しているが、下方に湾曲していてもこのクリックアクションは得られる。

このような弾性導電曲面板3の上方には、前記押しボタン1の下端が当接あるいは近接した状態で位置している。この押しボタン1は、その胴部1Bが前記上部スイッチケース2Aに形成さ

れた貫通孔2D内に上下に摺動自在に挿入されており、上端の拡開された頭部1Aが貫通孔2Dの上部に露出している。

以上のように構成された本考案の可変抵抗スイッチ10を動作させる時は、押しボタン1を下方に押圧するとその下端が弾性導電曲面板3を下方に押圧する。弾性導電曲面板3はこの押圧により、長手方向両端部が上方に湾曲した状態から平面状態を経由して、短手方向両端部が上方に湾曲した状態に変化し、クリックアクションを生じる。そして、前述のように弾性導電曲面板3はクリックアクションを生じた時点で、第7図に示すようにその下方に位置する電極4Bに接し、端子4C・端子4D間を導通させる。この状態が本考案の可変抵抗スイッチ10のオン動作点である。

さらに押しボタン1の押圧を続けると、第8図に示すように弾性導電曲面板3は下方に湾曲し、ブリッジ電極7がこの弾性導電曲面板3を介して押しボタン1に押圧され、その下方に位

置する感圧導電性ゴム6も押圧される。すると、この感圧導電性ゴム6の厚さ方向の抵抗値が減少し、この方向に電流が流れ易くなる。この状態が本考案の可変抵抗スイッチ10の可変抵抗動作開始点であり、電流が一方の端子5Cから感圧導電性ゴム6を介してブリッジ電極7の導電層7Aを通り、更に感圧導電性ゴム6を介して他方の端子5Dへと流れることができるようになる。

さらに押しボタン1を押圧すると、感圧導電性ゴム6が圧縮されてその抵抗値が減るので、端子5C－端子5D間の抵抗値は徐々に減少する。また、途中で押しボタン1の押圧力を緩めると、感圧導電性ゴム6は弾性力で元の状態に戻ろうとするので、その抵抗値は増大する。

そして、前述の押圧動作をやめると、まず、感圧導電性ゴム6が弾性力で無負荷の状態まで復帰し、その厚さ方向の抵抗値が無限大となって端子5C－端子5D間の導通がなくなり、次に、弾性導電曲面板3の復元力によって押しボタン1が押し上げられ、弾性導電曲面板3は無負荷

時の状態の位置に戻って電極4Bには接触しなくなるので、端子4C−端子4D間が非導通状態となる。

本考案の可変抵抗スイッチ10は以上のように動作するので、弾性導電曲面板3の形状変化によるスイッチの端子4C−端子4D間の導通（オン）動作が押圧感覚で容易に押しボタン1を押す操作者に理解でき、また、さらに押しボタンを押し続ければ、端子5C−端子5D間の抵抗値の変化を制御することが可能である。さらにまた、オン、オフ動作を行う端子と抵抗値が変化する端子とが一対ずつあるので、両者を別々の用途に使用することも可能である。

なお、オン、オフ端子4C，4Dに流す電流と、可変抵抗端子5C，5Dに流す電流とを分ける必要がない場合は、第9図に示すように前記ブリッジ電極7と、可変抵抗端子5C，5Dのうちの一方は必要がなくなる。

このように、可変抵抗器にスイッチ機能を付加することによって、例えば可変抵抗器用のア

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ンプへの電源を必要時以外カットしたり、モータのスピードコントロールを行う場合でレギュレータ回路を短絡する必要がある場合に、押圧するとまずスイッチが入ってレギュレータ回路を短絡し、次に抵抗値が変化するというような機能を1つのスイッチで実現することができるので、本考案の可変抵抗スイッチの用途は非常に広い。

〔考案の効果〕

以上説明したように本考案の可変抵抗スイッチは、ケース底部に設けられた二対の電極と、ケース内でそのうちの一対の電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないように一端がケースに、他端が残りの一対の電極のうちの一方の端部に支持され、押圧により曲率中心を通る母線方向が直角方向に変化する弾性導電曲面板と、この曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンとから構成されていることにより、押圧操作時にオフ状態から

オン状態に切り換わったことが操作者に明確に判断でき、さらに押しボタンを押し続けると2つの端子間の抵抗値を変化させることができるというオン、オフスイッチの機能と可変抵抗の機能とを1つのスイッチで実現できるという優れた効果があり、その応用範囲が広いという利点がある。

4．図面の簡単な説明

第1図〜第4図は本考案の可変抵抗スイッチの一実施例の構造を示すもので、第1図は平断面図、第2図は底面図、第3図は縦断面図、第4図は第3図のⅣ−Ⅳ線における縦断面図、第5図は本考案の可変抵抗スイッチに使用する弾性導電曲面板の斜視図、第6図は第5図の弾性導電曲面板の押圧による変形状態を示す斜視図、第7図は本考案の可変抵抗スイッチを軽く押圧した状態を示す縦断面図、第8図は本考案の可変抵抗をさらに押圧した状態を示す縦断面図、第9図は本考案の可変抵抗スイッチの他の実施例の構成を示す縦断面図である。

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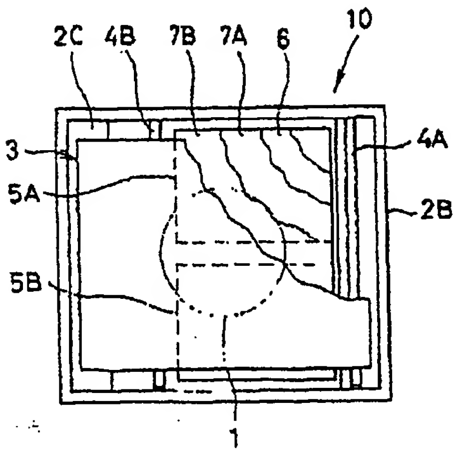
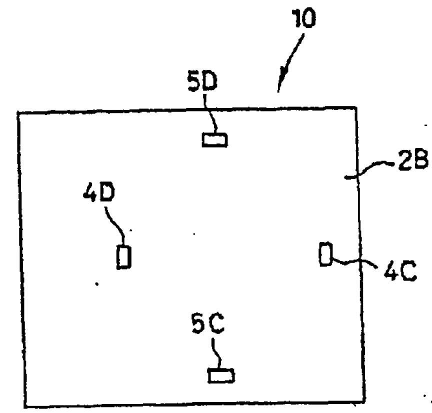
1…押しボタン、2A…上部スイッチケース、2B…下部スイッチケース、2C…段部、3…弾性導電曲面板、4A,4B,5A,5B…電極、4C,4D,5C,5D…端子、6…感圧導電性ゴム、7…ブリッジ電極、7A…導電層、7B…絶縁層、8，9…母線、10…本考案の可変抵抗スイッチ。

代理人　弁理士　小　川　信
　　　　弁理士　野　口　賢　照
　　　　弁理士　斎　下　和　彦

[redacted] [redacted]



第 1 図



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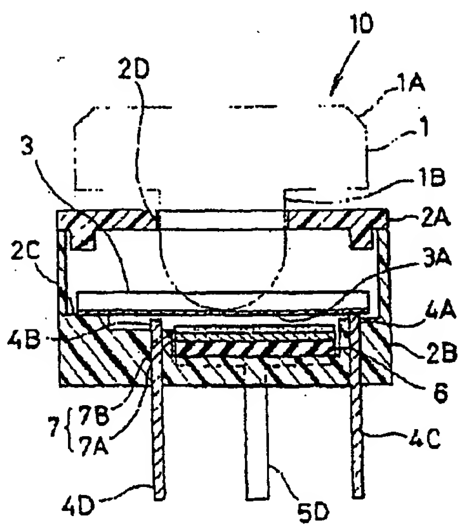

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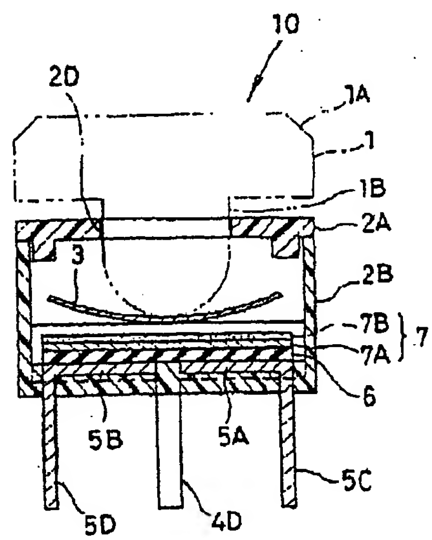

第 4 図

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ほか2名

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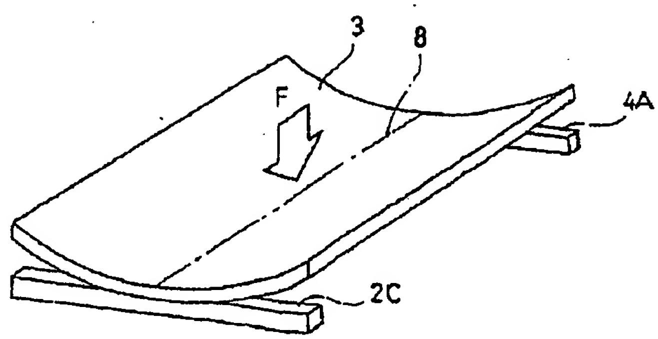
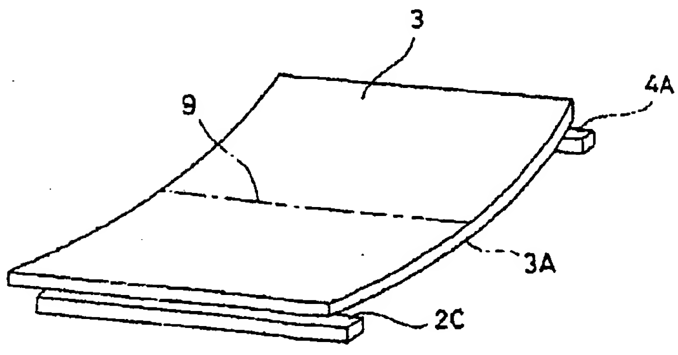
第 5 図



第 6 図



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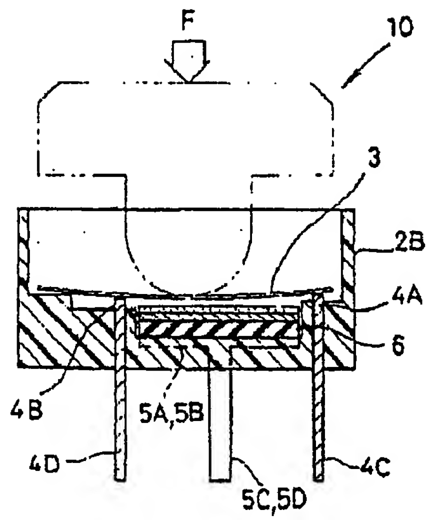
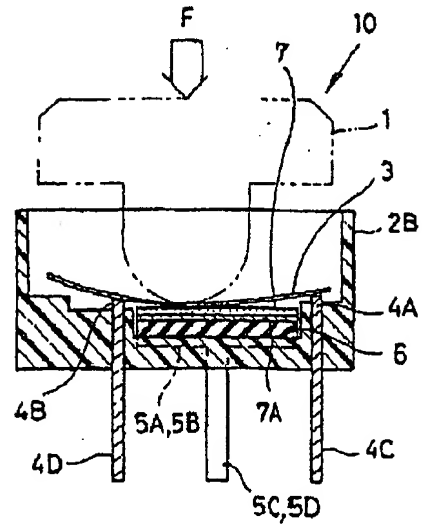
代理人 弁理士 小 川 信 一

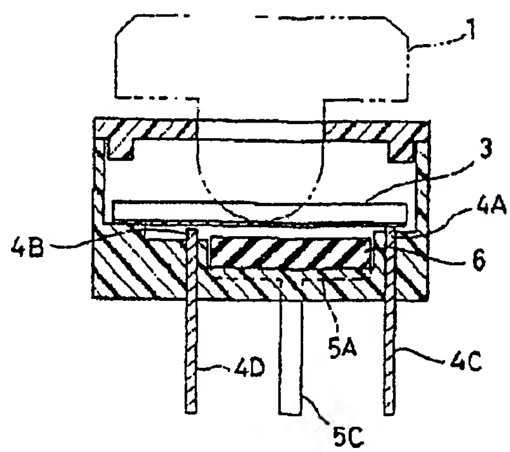
ほか 2 名



第 7 図



第 8 図



第 9 図

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Laid-Open Utility Model S61-103836

		(19) Japan Patent Office (JP) (12) Laid-Open Utility Model Publication (U)	(11) Laid-Open Utility Model Application Publication S61-103836
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(54) Title of the invention Variable resistance switch

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Laid-Open Utility Model S61-103836

Specification

1. Title of the invention
   Variable resistance switch

2. Utility Model Registration Claims
   A variable resistance switch comprising two pairs of electrodes provided at the bottom of a case, a flat plate of pressure-sensitive electro-conductive rubber provided on one of said pairs of electrodes within said case, an elastic electro-conductive curved plate supported by said case at one end and by the end of one of the other pair of electrodes at the other end so that it is not in contact with the top surface of said pressure-sensitive electro-conductive rubber and of which the generation line direction passing through the center of curvature is changed orthogonally in response to pressure, and a push button having a bottom end abutting or residing near said curved plate and a top end exposed from said case.

3. Detailed explanation of the invention
   [Scope of the invention]

The present invention relates to a variable resistance switch of which the on/off switching can be easily recognized through the feeling of pressure on a fingertip and the resistance between two terminals can be changed depending on how much the push button of the switch is pressed.

[Prior art technology]

Prior art pressure-sensitive elements, particularly variable resistance switches using pressure-sensitive electro-conductive rubber comprise a pair of electrodes at the bottom of a switch case and a pressure-sensitive electro-conductive rubber on top of it wherein the pressure-sensitive electro-conductive rubber is pressured at the top surface through a push button to change the resistance of the pressure-sensitive electro-conductive rubber.

In such a variable resistance switch, when the push button is pressed while the switch is off, there is no switchover point (click action) to indicate when it is turned on in the course of operation to activate the variable resistance function from the off-state. The operator of the push button often experiences difficulty in using such a switch.

[Purpose of the invention]

The purpose of the present invention is to resolve the above problems with the prior art variable resistance switch and to provide an excellent variable resistance switch in which a switchover point (click point) is provided in the middle of the stroke of the push button so that the operator clearly recognizes switching from the off-state to the on-state in the course of the pressing operation,

and the resistance between two terminals is changed when the push button is further pressed.

[Structure of the invention]

In order to achieve the above purpose, the variable resistance switch of the present invention is characterized by comprising two pairs of electrodes provided at the bottom of a case, a flat plate of pressure-sensitive electro-conductive rubber provided on one of the pairs of electrodes within the case, an elastic electro-conductive curved plate supported by the case at one end and by the end of one of the other pair of electrodes at the other end so that it is not in contact with the top surface of the pressure-sensitive electro-conductive rubber and of which the generation line direction passing through the center of curvature is orthogonally changed in response to pressure, and a push button having a bottom end abutting or residing near the curved plate and a top end exposed from the case.

[Embodiments]

Embodiments of the present invention are described hereafter with reference to the drawings.

Figs. 1 to 4 are a plane cross-sectional view, a bottom view, and cross-sectional views in directions orthogonal to each other, respectively, showing the structure of a variable resistance switch 10 according to an embodiment of the present invention.

The variable resistance switch 10 of this embodiment comprises a lower switch case 2B, an upper switch case 2A covering it, and a push button 1 exposed above the upper switch case 2A. Two pairs of electrodes 4A, 4B, 5A, and 5B are provided at the bottom of the lower switch case 2B at specific distances. The ends of the electrodes A, 4B, 5A, and 5B protrude from the bottom of the lower switch case 2B as terminals 4C, 4D, 5C, and 5D.

Among these electrodes, on a pair of electrodes 5A, 5B provided is a flat plate of pressure-sensitive electro-conductive rubber 6 having a uniform thickness to link the electrodes 5A and 5B together. A bridge electrode 7 is provided on the pressure-sensitive electro-conductive rubber 6 to cover it. The bridge electrode 7 consists of an electro-conductive layer 7A and an insulating layer 7B. The electro-conductive layer 7A is on the pressure-sensitive electro-conductive rubber 6 side. The pressure-sensitive electro-conductive rubber 6 is not electro-conductive unless it is pressured.

It has a variable resistance depending on the pressure. Therefore, the electrodes 5A and 5B are insulated from each other under no load.

An elastic electro-conductive curved plate 3 is provided above the bridge electrode 7. The elastic electro-conductive curved plate 3 is supported by a step 2C within the case at one end and by one of the pair of electrodes 4A, 4B, for example, the electrode 4A, at the other end so that it is not in contact with the bridge electrode 7. As shown in Fig.5, with the longitudinal ends being curved upward, the elastic electro-conductive curved plate 3 has a concave surface facing upward, supported by the step 2C formed on a sidewall of the lower switch case 2B at one end of the generating line 8 passing through the center of curvature resting thereon and by the electrode 4A at the other end. The electrode 4B, which is closer to the step 2C and pairs with the electrode 4A, is at a lower level than step 2C. Furthermore, the top surface of the bridge electrode 7 is at a lower level than electrode 4B. Therefore, the elastic electro-conductive curved plate 3 is not in contact with the electrode 4B and bridge electrode 7.

The elastic electro-conductive curved plate 3 is, for example, made of a phosphor bronze of approximately 80 μ having spring-like properties. When pressed at the center of the generating line 8 on the concave surface side with a force indicated by an arrow F, the concave surface is elastically deformed and changes its orientation in the click action. The generating line 8 changes its orientation orthogonally to a generating line 9 shown in Fig.6.

The distance between the electrode 4B and the step 2C of the lower switch case 2B is adjusted so that, in the above process, the bottom surface 3A of the elastic electro-conductive curved plate 3 makes contact with the electrode 4B. Further pressed, the elastic electro-conductive curved plate 3 is curved downward and makes contact with and pushes down the bridge electrode 7.

In this embodiment, the elastic electro-conductive curved plate 3 has the longitudinal ends curved upward. However, the longitudinal ends curved downward yield the same click action.

A push button 1 is provided above the elastic electro-conductive curved plate 3 with the bottom end abutting or residing near it.

The push button 1 has a body 1B that is vertically slidably inserted in a through-hole 2D formed in the upper switch case 2A and a head 1A having an extended top and exposed above the through-hole 2D.

For operating the variable resistance switch 10 of the present invention having the above structure, the push button 1 is pressed down so that its bottom end presses the elastic electro-conductive curved plate 3 downward. With this pressing, the elastic electro-conductive curved plate 3 changes its state from the one in which the longitudinal ends are curved upward to the other in which the transverse ends are curved upward via a flat state. This is a click action. When the elastic electro-conductive curved plate 3 undergoes the click action described above, it makes contact with the electrode 4B below it and establishes a conductive path between the terminals 4C and 4D, as shown in Fig.7. In this state, the variable resistance switch 10 of the present invention is at the switch-on point.

With the push button 1 being further pressed, the elastic electro-conductive curved plate 3 is curved downward as shown in Fig.8. Then, the bridge electrode 7 is pressed by the push button 1 via the elastic electro-conductive curved plate 3 and, subsequently, the pressure-sensitive electro-conductive rubber 6 below the bridge electrode 7 is pressed.

Then, the resistance through the thickness of the pressure-sensitive electro-conductive rubber 6 is reduced, which allows the electric current to easily flow. In this state, the variable resistance switch 10 of the present invention is at the variable resistance operation start point where the electric current flows from one terminal 5C to the electro-conductive layer 7A of the bridge electrode 7 via the pressure-sensitive electro-conductive rubber 6 and further to the other terminal 5D via the pressure-sensitive electro-conductive rubber 6.

With the push button 1 being further pressed, the pressure-sensitive electro-conductive rubber 6 is compressed and has reduced resistance, gradually reducing the resistance between the terminals 5C and 5D. On the other hand, with the pressure on the push button 1 being released, the pressure-sensitive electro-conductive rubber 6 tends to return to its original-state due to elasticity and the resistance is increased.

When the pressing is discontinued, first, the pressure-sensitive electro-conductive rubber 6 returns to its no-load state due to elasticity; then, the resistance through the thickness reaches an infinite value, nujllifying the conductivity between the terminals 5C and 5D. Then, the restoration of the elastic electro-conductive curved plate 3 pushes up the push button 1 and the elastic electro-conductive curved plate 3 returns to its no-load state so that it is no longer in contact with the electrode 4B, nullifying the conductivity between the terminals 4C and 4D.

(8)

The variable resistance switch 10 of the present invention operates as described above. The operator pressing the push button 1 can easily recognize the establishment of conductivity (ON) through the feeling of pressure between the terminals 4C and 4D of the switch as a result of the change in shape of the elastic electro-conductive curved pate 3. By further pressing the push button, he/she can control the change in resistance between the terminals 5C and 5D. Furthermore, two separate pairs of terminals, used for different purposes, are provided for the on/off operation and for the resistance change.

When the electric current through the on/off terminals 4C and 4D and the electric current through the variable resistance terminals 5C and 5D are not separated, either the bridge electrode 7 or the variable resistance terminals 5C, 5D are unnecessary.

As described above, by adding a switch function to a variable resistor, a single switch can be used, for example, to disconnect the power to an amplifier for a variable resistor when it is not in use or to first turn on a switch to short-circuit a regulator circuit and then change the resistance in controlling the motor speed when the regulator circuit should be short-circuited. The variable resistance switch of the present invention has extensive applications.

[Effects of the invention]

As described above, the variable resistance switch of the present invention comprises two pairs of electrodes provided at the bottom of a case, a flat plate of pressure-sensitive electro-conductive rubber provided on one of the pairs of electrodes within the case, an elastic electro-conductive curved plate supported by the case at one end and by the end of one of the other pair of electrodes at the other end so that it is not in contact with the top surface of the pressure-sensitive electro-conductive rubber and of which the generation line direction passing through the center of curvature is changed orthogonally in response to pressure, and a push button having a bottom end abutting or residing near the curved plate and a top end exposed from the case.

The operator can clearly recognize switching from the off-state to the on-state in the course of the pressing operation. With the push button being further pressed, the resistance between the two terminals is changed. In this way, the present invention has the efficacy that the on-off switching function and the variable resistance function are realized in a single switch and advantageously has extensive application.

4. Brief explanation of the drawings

Figs. 1 to 4 show the structure of an embodiment of the variable resistance switch of the present invention: Fig.1 is a plane cross-sectional view; Fig.2, a bottom view; Fig.3, a vertical cross-sectional view; and Fig.4, a vertical cross-sectional view at the line IV-IV in Fig.3. Fig.5 is a perspective view of the elastic electro-conductive curved plate used in the variable resistance switch of the present invention. Fig.6 is a perspective view of the elastic electro-conductive curved plate when it is deformed by pressing. Fig.7 is a vertical cross-sectional view of the variable resistance switch of the present invention when it is gently pressed. Fig.8 is a vertical cross-sectional view of the variable resistance switch of the present invention when it is further pressed. Fig.9 is a vertical cross-sectional view showing the structure of another embodiment of the variable resistance switch of the present invention.

1 ... push button, 2A ... upper switch case, 2B ... lower switch case, 2C ... step, 3 ... elastic electro-conductive curved plate, 4A, 4B, 5A, 5B ... electrode, 4C, 4D, 5C, 5D ... terminal, 6 ... pressure-sensitive electro-conductive rubber, 7 bridge electrode, 7A ... electro-conductive layer, 7B ... insulating layer, 8, 9 ... generating line, 10 ... variable resistance switch of the present invention.

Representatives Shin-ichi Ogawa, Patent Attorney
Masateru Noguchi, Patent Attorney
Kazuhiko Saishita, Patent Atoorney

(12)

Laid-Open Utility Model S61-103836

Fig.1 Fig.2
Fig.3 Fig.4

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Fig.5

Fig.6

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Fig.7 Fig.8

Fig.9

Representatives Shin-ichi Ogawa, Patent Attorney and two others

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25405, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Utility Model

S61-103836
"Variable Resistance Switch"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

October 24, 2006

公開実用 昭和53—128861

3,000円

(3,000円)

実用新案登録願

昭和52年3月23日

特許庁長官 片山石郎 殿

1. 考案の名称

感圧スイッチ機構

2. 考案者

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氏名 (2038)弁理士 奥山恵吉
(ほか1名)

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53-128861

方式審査

明　細　書

1.　考案の名称

感圧スイッチ機構

2.　実用新案登録請求の範囲

(1)　スイッチ素子として感圧抵抗体を用いて成るスイッチ本体と、一定圧力で反転するスプリングとを備え、上記スプリングを介して上記感圧抵抗体を押圧し、かつスプリングが反転した時に少なくとも感圧抵抗体が導通状態となる様に構成したことを特徴とする感圧スイッチ機構。

(2)　上記スプリングを、反転時の圧力が異なるスプリングに交換可能に備えたことを特徴とする実用新案登録請求の範囲第(1)項に記載した感圧スイッチ機構。

3.　考案の詳細な説明

本考案は感圧抵抗体をスイッチ素子として使用した感圧スイッチ機構に関する。さらに詳しくは、感圧抵抗体と一定圧力で反転するスプリングを組み合わせ、該スプリングを介して感圧

53-128661

抵抗体を押圧する様にした感圧スイッチ機構に関する。

従来、スイッチ構造としては金属接点とバネの組み合わせから構成されているものが一般的であるが、これは繰返し使用しているうちに、例えば接点間の火花放電による接点の劣化、または振動，衝撃に伴なう接点部のガタツキなどにより作動不良、あるいは誤動作等のトラブルを起こすことが少なくなかつた。

この様な従来の機械的スイッチに対し、近年感圧抵抗体を利用したスイッチが用いられる様になつてきた。この感圧抵抗体を利用したスイッチは、従来の機械的スイッチの欠点を解消するものであり、金属接点を有しないので火花放電および接点の劣化という問題がなく、振動又は衝撃に伴なう作動不良あるいは誤動作もなく、経年変化が少ないという特徴を有している。

しかし、この様な感圧抵抗体を利用したスイッチの一般的な構造は、2枚の電極板間に感圧抵抗体を介在させた構造であり、従つて、たと

えば手でスイツチを押圧してオン－オフ作動を行なわせる場合、どの程度押圧すればオン状態になるのかがはつきりせず、スイツチのオン－オフ作動を確実に感知することが困難であつた。さらに、スイツチのオン－オフ作動圧力を変更する場合、所望の感圧力を有する感圧抵抗体を用意し、その感圧抵抗体に取り換えなければならなかつた。

本考案の目的は、上記事情に鑑み、スイツチを操作する人がオン状態になつているか、オフ状態になつているか、即ちスイツチが確実に作動しているかどうかをクリック感によつて感知することができ、さらに感圧抵抗体を取り換えることなくスイツチの作動圧力を変更することができる感圧スイツチ機構を提供することにあり、その要旨は、感圧抵抗体と一定圧力で反転するスプリングとを備え、上記スプリングを介して上記感圧抵抗体を押圧し、かつスプリングが反転した時に少なくとも上記感圧抵抗体が導通状態になる様に構成したことを特徴とする感

圧スイッチ機構にある。

以下、図面に示す実施例を参照しながら本考案を詳細に説明する。

感圧抵抗体とは、ゴムまたは合成樹脂たとえばシリコンゴム，SBR，NBR，EPDM，IR，アクリルゴムのような弾性絶縁体中に金属粒子あるいは導電性カーボンなどの導電性粒子を体積分率で5～50％程度分散混合したもので、印加した圧力によつて弾性変形し電気抵抗または導電率が変化するという性質を有するものである。

第1図は本考案に係る感圧スイッチ機構に使用する感圧抵抗体の印加圧力に対する体積固有抵抗値の変化と、これに対応した感圧抵抗体の圧縮率との関係を示したものである。本考案は、同図にみられる様に、抵抗が無加圧状態において10^6Ω-cm以上であり、かつ加圧した場合10^3Ω-cm以下になるような感圧抵抗体をスイッチ素子として使用するものである。

第2図は本考案におけるスイッチ本体の一例

を示すものであり、その構造は、先に本出願人が提案したもの（実願昭51-113897号）と同一である。図において、1は感圧抵抗体、2は加圧板、3a,3bは電極板、4は非導電性部材、5は電極仕切板、6は支持体、6aはストッパー、7a,7bはリード線である。即ち、感圧抵抗体1の上面には加圧板2を配設し、下面には2枚の電極板3a,3bを配設し、周囲には弾性を有する非導電性部材4を配設してある。上記電極板3a,3bはその間に配置された絶縁性の電極仕切板5によつて互いに絶縁されている。電極板3a,3bの下側には支持体6を配置し、この支持体6の周縁部には上方の加圧板2に向かつて突出したストッパー6aを形成してある。ストッパー6aの上端と加圧板2との間には所定間隔ℓを設けてあり、加圧板2が押圧され距離ℓだけ押し下げられるとストッパー6aに当接する様にしてある。又、上記電極板3a,3bにはそれぞれリード線7a,7bを接続してある。

このスイッチ本体は、加圧板2に圧力を印加

して感圧抵抗体1を圧縮すると、感圧抵抗体1の電気抵抗が減少し、リード線7a－電極板3a－感圧抵抗体1－電極板3b－リード線7bと回路が形成されて導通状態となる。そして、さらに圧力を印加すると加圧板2はストッパー6aに当接し、感圧抵抗体5の受ける圧縮変形量が制御され、過剰の圧縮が防止される。

このスイッチ本体は、ストッパー6aを設けたので過剰圧縮による感圧抵抗体1の力学的劣化が防止でき、又、電極板3a,3bの取付け位置を感圧抵抗体1の底面部とすることにより加圧時における電極板3a,3bの歪を小さくしたので繰返し使用に伴なう電極板の劣化が殆んどなく、スイッチの寿命が伸び、さらに感圧抵抗体1と電極板3a,3bの接点部を完全にシールしたので耐環境性に優れている等の特徴を有する。

第3図は、第2図に示したスイッチ本体を使用した本考案に係る感圧スイッチ機構を示す断面概念図である。

本感圧スイッチ機構は、図に示す様に、ケー

公開実用 昭和53— 128861

(3,000円)

実用新案登録願

昭和52年 3 月23日

特許庁長官 片 山 石 郎 殿

1. 考案の名称

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明　細　書

1.　考案の名称

感圧スイッチ機構

2.　実用新案登録請求の範囲

(1)　スイッチ素子として感圧抵抗体を用いて成るスイッチ本体と、一定圧力で反転するスプリングとを備え、上記スプリングを介して上記感圧抵抗体を押圧し、かつスプリングが反転した時に少なくとも感圧抵抗体が導通状態となる様に構成したことを特徴とする感圧スイッチ機構。

(2)　上記スプリングを、反転時の圧力が異なるスプリングに交換可能に備えたことを特徴とする実用新案登録請求の範囲第(1)項に記載した感圧スイッチ機構。

3.　考案の詳細な説明

本考案は感圧抵抗体をスイッチ素子として使用した感圧スイッチ機構に関する。さらに詳しくは、感圧抵抗体と一定圧力で反転するスプリングを組み合わせ、該スプリングを介して感圧

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抵抗体を押圧する様にした感圧スイッチ機構に関する。

従来、スイッチ構造としては金属接点とバネの組み合わせから構成されているものが一般的であるが、これは繰返し使用しているうちに、例えば接点間の火花放電による接点の劣化、または振動，衝撃に伴なう接点部のガタツキなどにより作動不良、あるいは誤動作等のトラブルを起こすことが少なくなかつた。

この様な従来の機械的スイッチに対し、近年感圧抵抗体を利用したスイッチが用いられる様になつてきた。この感圧抵抗体を利用したスイッチは、従来の機械的スイッチの欠点を解消するものであり、金属接点を有しないので火花放電および接点の劣化という問題がなく、振動又は衝撃に伴なう作動不良あるいは誤動作もなく、経年変化が少ないという特徴を有している。

しかし、この様な感圧抵抗体を利用したスイッチの一般的な構造は、2枚の電極板間に感圧抵抗体を介在させた構造であり、従つて、たと

えば手でスイッチを押圧してオン－オフ作動を行なわせる場合、どの程度押圧すればオン状態になるのかがはつきりせず、スイッチのオン－オフ作動を確実に感知することが困難であつた。さらに、スイッチのオン－オフ作動圧力を変更する場合、所望の感圧力を有する感圧抵抗体を用意し、その感圧抵抗体に取り換えなければならなかつた。

本考案の目的は、上記事情に鑑み、スイッチを操作する人がオン状態になつているか、オフ状態になつているか、即ちスイッチが確実に作動しているかどうかをクリック感によつて感知することができ、さらに感圧抵抗体を取り換えることなくスイッチの作動圧力を変更することができる感圧スイッチ機構を提供することにあり、その要旨は、感圧抵抗体と一定圧力で反転するスプリングとを備え、上記スプリングを介して上記感圧抵抗体を押圧し、かつスプリングが反転した時に少なくとも上記感圧抵抗体が導通状態になる様に構成したことを特徴とする感

圧スイッチ機構にある。

以下、図面に示す実施例を参照しながら本考案を詳細に説明する。

感圧抵抗体とは、ゴムまたは合成樹脂たとえばシリコンゴム，SBR，NBR，EPDM，IR，アクリルゴムのような弾性絶縁体中に金属粒子あるいは導電性カーボンなどの導電性粒子を体積分率で5～50％程度分散混合したもので、印加した圧力によつて弾性変形し電気抵抗または導電率が変化するという性質を有するものである。

第1図は本考案に係る感圧スイッチ機構に使用する感圧抵抗体の印加圧力に対する体積固有抵抗値の変化と、これに対応した感圧抵抗体の圧縮率との関係を示したものである。本考案は、同図にみられる様に、抵抗が無加圧状態において10^{6}Ω-cm以上であり、かつ加圧した場合10^{3}Ω-cm以下になるような感圧抵抗体をスイッチ素子として使用するものである。

第2図は本考案におけるスイッチ本体の一例

を示すものであり、その構造は、先に本出願人が提案したもの（実願昭51-113897号）と同一である。図において、1は感圧抵抗体、2は加圧板、3a,3bは電極板、4は非導電性部材、5は電極仕切板、6は支持体、6aはストッパー、7a,7bはリード線である。即ち、感圧抵抗体1の上面には加圧板2を配設し、下面には2枚の電極板3a,3bを配設し、周囲には弾性を有する非導電性部材4を配設してある。上記電極板3a,3bはその間に配置された絶縁性の電極仕切板5によつて互いに絶縁されている。電極板3a,3bの下側には支持体6を配置し、この支持体6の周縁部には上方の加圧板2に向かつて突出したストッパー6aを形成してある。ストッパー6aの上端と加圧板2との間には所定間隔ℓを設けてあり、加圧板2が押圧され距離ℓだけ押し下げられるとストッパー6aに当接する様にしてある。又、上記電極板3a,3bにはそれぞれリード線7a,7bを接続してある。

このスイッチ本体は、加圧板2に圧力を印加

して感圧抵抗体1を圧縮すると、感圧抵抗体1の電気抵抗が減少し、リード線7a－電極板3a－感圧抵抗体1－電極板3b－リード線7bと回路が形成されて導通状態となる。そして、さらに圧力を印加すると加圧板2はストッパー6aに当接し、感圧抵抗体5の受ける圧縮変形量が制御され、過剰の圧縮が防止される。

このスイッチ本体は、ストッパー6aを設けたので過剰圧縮による感圧抵抗体1の力学的劣化が防止でき、又、電極板3a,3bの取付け位置を感圧抵抗体1の底面部とすることにより加圧時における電極板3a,3bの歪を小さくしたので繰返し使用に伴なう電極板の劣化が殆んどなく、スイッチの寿命が伸び、さらに感圧抵抗体1と電極板3a,3bの接点部を完全にシールしたので耐環境性に優れている等の特徴を有する。

第3図は、第2図に示したスイッチ本体を使用した本考案に係る感圧スイッチ機構を示す断面概念図である。

本感圧スイッチ機構は、図に示す様に、ケー

ス9内の下方に保持部材10a,10bを介してスイッチ本体8を配置してある。このスイッチ本体8は第2図に示すスイッチ本体と同じものであり、附記した番号も第2図と同じである。このスイッチ本体8はその加圧板2が上になるように配置され、その上方に加圧棒11を配置してある。加圧棒11の上端は一定圧力で反転するスプリング12に固定してある。スプリング12の形状は、板バネのような反転可能な上に凸形である。さらにこのスプリング12のすぐ上には本スイッチ機構をカバーするゴムシートあるいはダイヤフラム13を配置してある。

従つて、指または他の押圧手段によつてゴムシートあるいはダイヤフラム13を押すと加圧力がスプリング12に加わつてスプリング12を反転させ、この反転によりスプリング12に固定された加圧棒11が加圧棒の下方に配置されたスイッチ本体の加圧板2を押圧し、感圧抵抗体1が導通状態となり、リード線7a,7bが導通状態となる。即ち、本感圧スイッチ機構はスプリングの

反転に要する所定の圧力で作動する。

一方、スプリング12に圧力を加えてスプリング12を反転させる際に、その反撥力でクリック感が生じ、スイッチを操作する者はスイッチが確実に作動したことを感知出来る。また、ダイヤフラム又はゴムシート13を使用しかつスプリング12の材質，形状を選ぶことにより反転に要する圧力を所定の圧力に設定することが出来るので、スイッチのオン－オフ作動圧力を、感圧抵抗体を変えることなく、任意に変更することができる。

第4図は本感圧スイッチ機構に使用したスプリングの圧力－歪み特性と、この特性に基づくスイッチの作動状態を示すものである。即ち、スプリングの歪み量は圧力の上昇と共に増加し、所定の圧力P_2に到達した際反転を起こし、この時点でスイッチはオフ状態からオン状態となる。次いで圧力が減少するにつれて歪み量が低下しはじめ、ある圧力P_1で再度反転し、スイッチはオフ状態に戻る。

なお、本考案に係る感圧スイッチ機構は図示した実施例に限定されるものではなく、たとえはスイッチ本体としては感圧抵抗体を用い、加圧することによりオン－オフ作動を行うスイッチであればよく、スプリングも金属，樹脂，ゴム等を素材とした、一定圧力で反転可能な形状のものであればよい。その他の構造も本発明の要旨を超えない限り種々の変形が可能である。

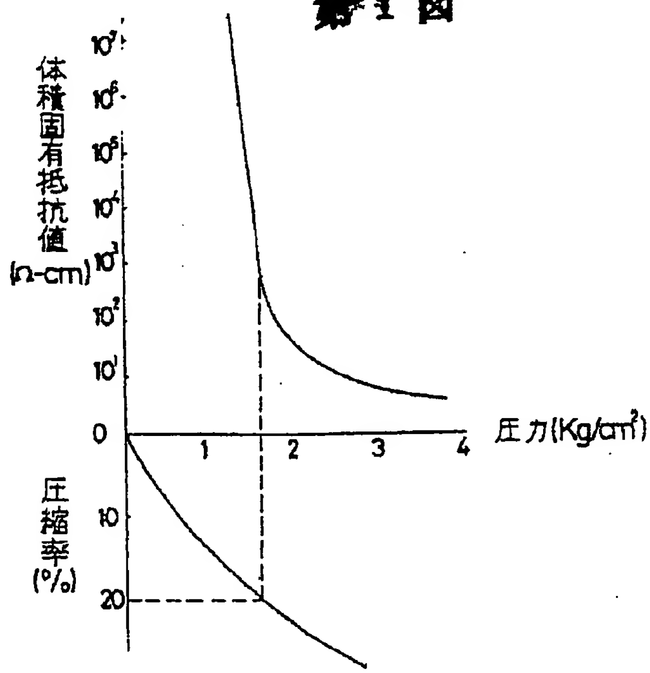
以上の様に本考案に係る感圧スイッチ機構は、一定圧力で反転するスプリングを介して感圧抵抗体を押圧する様にしたので、スプリングの反転に要する所定の圧力でスイッチが作動し、スイッチを操作する者はスプリングが反転するときのクリック感によりスイッチの作動を確実に感知することができる。又スプリングの材質，形状を選ぶことにより反転に要する圧力を所定の圧力に設定することができることから圧力検出端の機能を持たせることができ、従つて本感圧スイッチ機構は圧力スイッチ，圧力安全装置等に適用することができる。

4. 図面の簡単な説明

第1図は本考案に係る感圧スイッチ機構に使用する感圧抵抗体の印加圧力に対する体積固有抵抗値とこれに対応した感圧抵抗体の圧縮率との関係を示すグラフ、第2図は感圧抵抗体をスイッチ素子として用いたスイッチ本体の一例を示す断面概念図、第3図は本考案に係る感圧スイッチ機構の一実施例を示す断面概念図、第4図はスプリングの圧力－歪み特性とその特性に基づくスイッチの作動状態を示す図である。

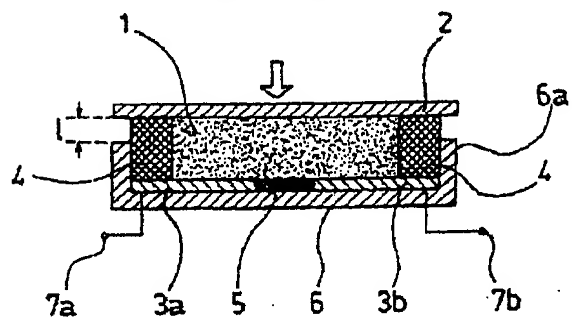
1…感圧抵抗体、2…加圧板、3a,3b…電極板、4…非導電性部材、5…電極仕切板、6…支持体、6a…ストッパー、7a,7b…リード線、8…スイッチ本体、9…ケース、10a,10b…保持体、11…加圧棒、12スプリング、13…ゴムシートあるいはダイヤフラム。

第1図



代理人 奥山恵吉 外一名

第2図



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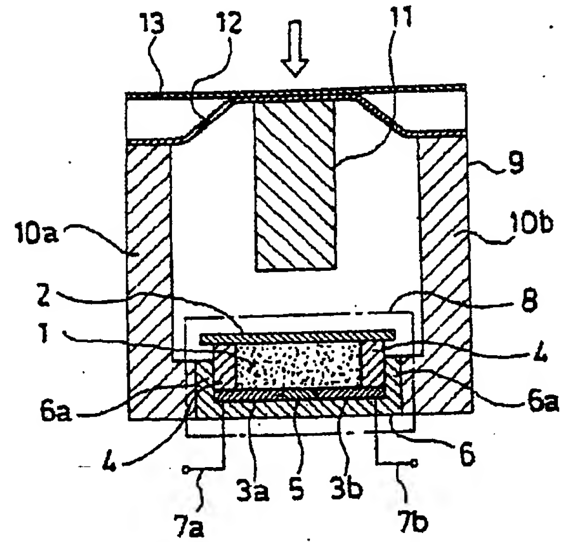
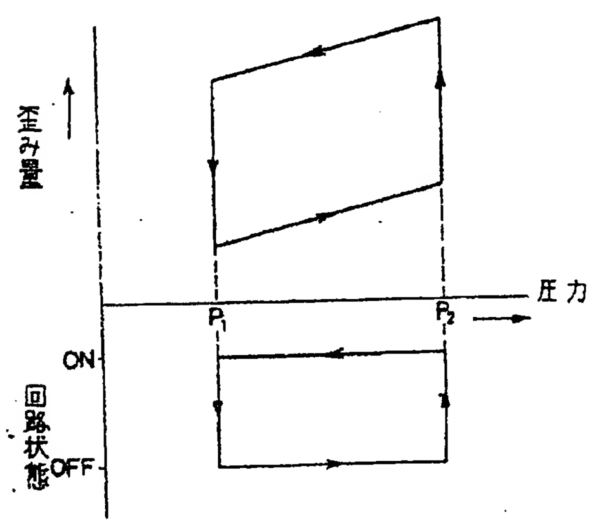
第3図


13
12
11
9
10a
10b
2
8
1
4
6a
6a
4
6
3a
5
3b
7a
7b

第4図


歪み量
圧力
P_1
P_2
ON
OFF
回路状態

5. 添附書類の目録

(1)	明細書	1通
(2)	図面	1通
(3)	願書副本	1通
(4)	委任状	1通

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53-128861

JAPANESE LAID-OPEN UTILITY MODEL APPLICATION

S53-128861 (1978)

Utility Model Application

March 23, 1977

Ishiro KATAYAMA Commissioner, Japan Patent Office

1. **Title of the Design**

   Pressure Sensitive Switch Mechanism

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52 034965 Formal Examination

53128861 (Fukui)

SPECIFICATION

1. Title of the design

Pressure Sensitive Switch Mechanism

2. Claims

(1) A pressure sensitive switch mechanism characterized by having a switch main body with a pressure sensitive resistor as a switching element and a spring inverting at a given pressure and so constructing it that the above pressure sensitive resistor is pushed via the above spring and at least the pressure sensitive resistor becomes the conductive state when inverting the spring.

(2) The pressure sensitive switch mechanism according to Claim 1 characterized by having the above spring that is exchangeable with a spring having a different pressure at the time of inversion.

3. Detailed description of the invention

The present design relates to a pressure sensitive switch mechanism using a pressure sensitive resistor as a switching element. Specifically, the present design relates to a pressure sensitive switch mechanism made such that the pressure sensitive resistor and a spring inverting at a given pressure are combined and the pressure sensitive resistor is pushed via the spring.

Conventional switch structures have generally been constructed from a combination of metal contacts and a spring, but when the switch is repeatedly used, often troubles such as poor operation or malfunction, etc. occur due to aging of contacts caused, for example, by a spark discharge between the contacts or shaking of the contacts accompanied by vibration and impact.

In contrast to such a conventional mechanical switch, a switch using a pressure sensitive resistor has recently come to be increasingly used, eliminating the drawbacks of a conventional mechanical switch, has no problems of spark discharge and aging of contacts because there are no metallic contacts, and there is no poor operation or malfunction accompanied by vibration and impact and fewere secular changes.

However, a general structure of the switch using such a pressure sensitive resistor is a structure in which a pressure sensitive resistor is interposed between two electrode plates,

accordingly, for example, when the switch is pushed by hand to conduct the ON-OFF operation, whether the switch becomes the ON state to any degree is not clear and it was difficult to reliably perceive the ON-OFF operation of the switch. When the ON-OFF operating pressure is changed, a pressure sensitive resistor having a desirable pressure-sensing force must be prepared to replace it by a pressure sensitive resistor.

In view of the above circumstance, the purpose of present design is to provide a pressure sensitive switch mechanism by which a person operating the switch may perceive whether the switch becomes the ON state or the OFF state, i.e. whether the switch reliably operates or not by a click feeling, and the operating pressure of the switch may be changed without replacing the pressure sensitive resistor, and it substantially consists of a pressure sensitive switch mechanism characterized by having a pressure sensitive resistor and a spring inverting at a given pressure, constituting it so that the above pressure sensitive resistor is pushed via the above spring and at least the pressure sensitive resistor becomes the conductive state when inverting the spring.

The present design is described in detail hereafter with reference to in the drawings.

The pressure sensitive resistor is achieved by dispersing and mixing about 5 ~ 50% by volume of conductive particles, such as metallic particles or conductive carbon, etc., in an elastic insulator like rubber or a synthetic resin, such as silicone rubber, SBR, NBR, EPDM, IR, acrylic rubber, etc. and has is characterized by elastically deforming due to impressed pressure to change the electrical resistance or conductivity. As is seen in the same drawings, a pressure sensitive resistor is used as a switching element, the resistance of which is 10^5 Ω-cm or greater in the non-pressure state and 10^3 Ω-cm or below when applying pressure.

Fig. 2 shows an example of a switch body according to the present design, the structure of which is the same as that formerly proposed by the present applicant (UM Appl. S51-113897). In the drawing, **1** is a pressure sensitive resistor, **2** is a pressure plate, **3a**, **3b** are electrode plates, **4** is a non-conductive member, **5** is an electrode partition plate, **6** is a support, **6a** is a stopper, and **7a**, **7b** are lead wires. Namely, the pressure plate **2** is arranged upside of pressure sensitive resistor 1, the two electrode plates **3a**, **3b** are arranged downside, and the non-conductive member **4** having elasticity is arranged around them. Electrode plates **3a**, **3b** are insulated from each other by the insulative electrode partition plate **5** arranged between them. A support **6** is arranged downside of electrode

plates **3a**, **3b**, **with a** stopper **6a** protruding to the upper pressure plate **2** being formed at the rim of the support **6**. A prescribed spacing l is provided between the upper end of stopper **6a** and the pressure plate **2**. If the pressure plate **2** is pushed down for only a distance l, it makes contact with the stopper **6a**. The lead wires **7a**, **7b** are connected to the above electrode plates **3a**, **3b**, respectively.

In this switch body, if pressure is impressed on the pressure plate **2** to compress the pressure sensitive resistor **1**, the electric resistance of pressure sensitive resistor **1** is reduced, and a lead wire **7a** - electrode plate **3a** - pressure sensitive resistor **1** - electrode plate **3b** - lead wire **7b** circuit is formed to become the conductive state. Then, if a pressure is impressed, the pressure plate **2** is in touch with the stopper **6a** to control the compressive deformation received by the electrode partition plate **5** and prevent it from excessive compression.

This switch body may prevent the mechanical aging caused by excessive compression because it is provided with a stopper **6a**, and it almost has no aging of the electrode plates accompanied by repeated use because the distortion of electrode plates **3a**, **3b** when applying pressure is reduced by using the mounting positions of the electrode plates **3a**, **3b** as the bottom surface of the pressure sensitive resistor **1**, and also has the features of excellent environment resistance, etc. because the contacts of pressure sensitive resistor **1** and electrode plates **3a**, **3b** are completely sealed.

Fig. 3 is a sectional conceptual drawing showing the pressure sensitive switch mechanism relating to the present design using the switch body shown in Fig. 2.

In this pressure sensitive switch mechanism, as shown in the drawing, a switch body **8** is arranged in the lower part in a case **9** via holding members **10a**, **10b**. Switch body **8** is same as the switch body shown in Fig. 2, and attached numbers are also same as Fig. 2. This switch body **8** is so arranged that the pressure plate **2** thereof becomes the upside, above which is arranged a pressure rod **11** is arranged above it. The upper end of pressure rod **11** is fixed to a spring **12** inverting at a given pressure. The shape of spring **12** is invertible and convex relative to the above like a plate spring. A rubber sheet or diaphragm **13** covering the switch mechanism is arranged immediately on the spring **12**.

Accordingly, if the rubber sheet or diaphragm **13** is pushed with a finger or another pushing

means, a pressure force is applied to the spring **12** to invert the spring **12**, the pressure rod **11** fixed to the spring **12** by this inversion pushes the pressure plate **2** of switch body **8** arranged below the pressure rod **11**, the pressure sensitive resistor **1** becomes the conductive state and the lead wires **7a**, **7b** become the conductive state. Namely, this pressure sensitive switch mechanism operates at a given pressure needed for the inversion of the spring.

On the other hand, when pressure is applied to the spring **12** to invert the spring **12**, a click feeling is generated by the repulsive force, and the person operating the switch may perceive that the switch is reliably operating. The pressure needed for the inversion may be set to a prescribed pressure by using the rubber sheet or diaphragm **13** and selecting the material and shape of spring **12**, therefore the ON-OFF operating pressure of switch may be arbitrarily selected without changing the pressure sensitive resistor **1**.

Fig. 4 shows the pressure-distortion characteristic of spring used in the pressure sensitive switch mechanism and the operating state of a switch based on this characteristic. Namely, the distortion of the spring increases with a rise of pressure, the inversion is caused when reaching a prescribed pressure P_2, and the switch goes from the OFF state to the ON state at this point in time. Subsequently, the distortion starts to lower with the reduction of pressure, the spring inverts again at some pressure P_1 and the switch returns to the OFF state.

The pressure sensitive switch mechanism relating to the present design is not restricted to the illustrated example. For example, it may be a switch for performing the ON-OFF operation by applying pressure using a pressure sensitive resistor as the switch body, and the switch may also be a shape made invertible at a given pressure using metal, resin or rubber, etc. as the material. Other various modifications of structure are also possible so long as they do not exceed the essence of the present design.

As described above, the pressure sensitive switch mechanism relating to the present design pushes the pressure sensitive resistor via the spring inverting at a given pressure, therefore the spring operates at a prescribed pressure needed for the inversion of spring, and a person operating the switch may reliably perceive the operation of the switch by a click feeling at the time of inverting the spring. The function of pressure detection termination may be discerned from the fact that the pressure required for the inversion may be set to a prescribed pressure by selecting the material and shape of

spring. Accordingly, this pressure sensitive switch mechanism may be applied to a pressure switch, a pressure safety device, etc.

4. Brief description of the drawings

Fig. 1 is a graph showing the relationship between the volume inherent resistance value and the compressiveness of a corresponding pressure sensitive resistor used in a pressure sensitive switch mechanism according to the present design versus the impressed pressure of the pressure sensitive resistor;

Fig. 2 is a sectional conceptual drawing showing an example of a switch body using the pressure sensitive resistor as the switching element;

Fig. 3 is a sectional conceptual drawing showing an example of a pressure sensitive switch mechanism according to the present design, and

Fig. 4 shows the pressure-distortion characteristic of the spring and the operating state of the switch based on this characteristic.

1 pressure sensitive resistor

1 pressure plate

3a, 3b electrode plates

4 non-conductive member

5 electrode partition plate

6 support

6a stopper

7a, 7b lead wires

8 switch body

9 case

10a, 10b holding members

11 pressure rod

12 spring

13 rubber sheet or diaphragm

5. List of attached documents

(1)	Specification	1
(2)	Drawings	1
(3)	Duplicate of application	1
(4)	Letter of attorney	1

6. Inventor and agents other than the above

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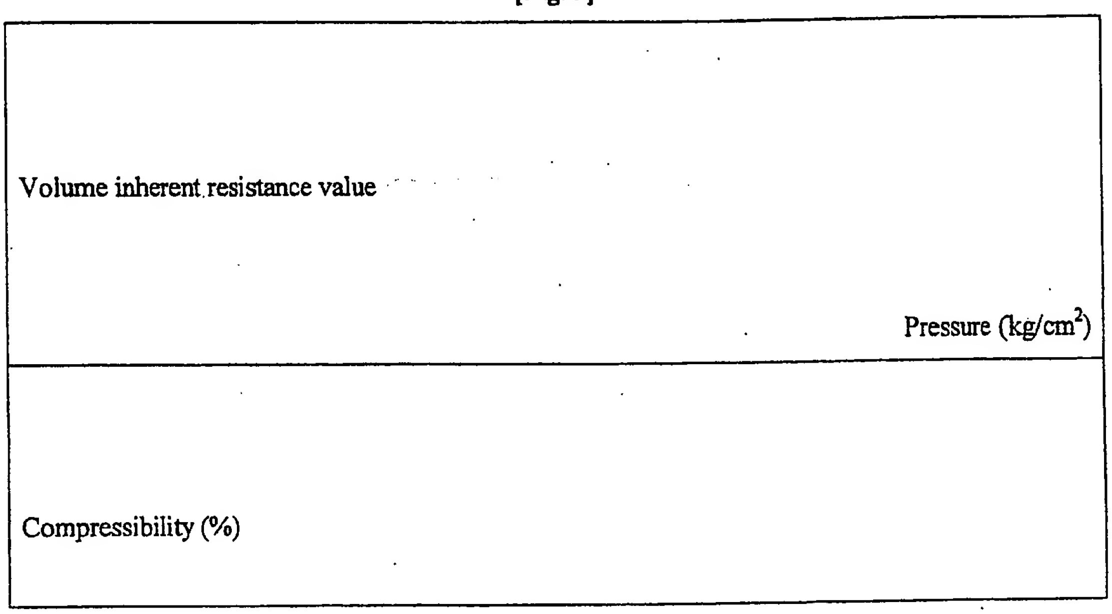
Name (6006) Attorney **Hisao OKUYAMA**

[Fig. 1]



[Fig. 2]

[Fig. 3]

[Fig. 4]

Distortion (Ω-cm)

Pressure (kg/cm^2)

State of circuit (%)

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25405, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Utility Model
S53-128861 (1978)
"Pressure Sensitive Switch Mechanism"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

October 24, 2006

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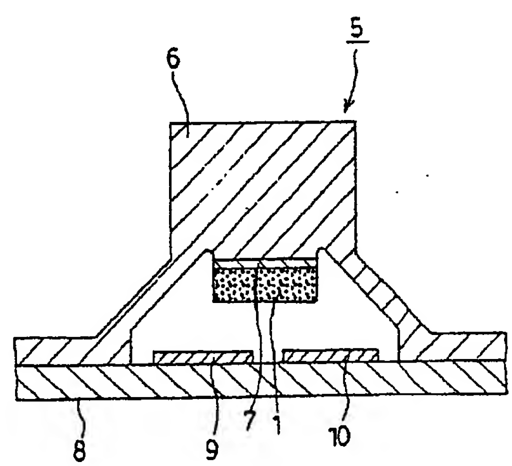
(54)【発明の名称】　感圧可変抵抗器

(57)【要約】
【目的】　キーボードスイッチ等に容易に応用できる可変抵抗器を提供する。
【構成】　カーボンブラックやグラファイト等の炭素粉末をシリコンゴム材に混合し、一体成形して感圧可変抵抗器１を成形する。この感圧可変抵抗器１を、例えばスイッチ５に応用する場合は、キートップ６の下面に導電層７を介して感圧可変抵抗器１を設ける。キートップ６を押下げると、感圧可変抵抗器１が固定接点９，１０に当接する。押圧力によって炭素粉末間の接触圧が高まり、固定接点９，１０と導電層７を導通させる異方性導電作用が表われる。押圧力に対応して感圧可変抵抗器１の抵抗値が変化し、固定接点９，１０間の電圧を任意に手動操作できる。



NAA00002678

【特許請求の範囲】

【請求項1】　導電物質を弾性ゴム材に混合して一体成形し、異方導電性を付与した感圧可変抵抗器。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は可変抵抗器に関するものであり、特にソリッド構造の可変抵抗器に関するものである。

【0002】

【従来の技術】従来、抵抗体と摺動接点とにより構成された可変抵抗器が、回路電圧の調整用に使用されている。また、応力に対して電気抵抗が変化する半導体感圧素子の特性を利用したストレーンゲージ等のセンサは広く知られている。

【0003】

【発明が解決しようとする課題】例えば、コンピュータのカーソル移動キーやスクロールキー、自動車のパワーウインドウスイッチ等は単にオンとオフを切換えるスイッチである。之等のキー或いはスイッチに、操作者の意志に応じてアナログ的に操作量を調整することが可能な機能を付加すれば、所謂マンマシンインタフェースとしての性能向上が期待できる。

【0004】このアナログ的操作を実現するためには、ハードウエアやソフトウエアを変更しなければならないことは当然ながら、キー或いはスイッチに電気量操作手段として可変抵抗器を使用することが必要となる。しかし、従来の可変抵抗器を之等のキーやスイッチに応用することは、体積、重量、耐久性やコスト等において問題がある。例えば、従来の機械式の可変抵抗器をキーボードのキーに用いることは、スペース的にも耐久性や操作性についても問題が生ずる。

【0005】そこで、この発明は簡素な構成で高耐久性を有し、操作感覚に見合った抵抗変化を得ることができ、且つ低コストの可変抵抗器を提供してエレクトロニクス機器の機能の向上に寄与することを目的とする。

【0006】

【課題を解決するための手段】この発明は上記目的を達成するために、炭素粉末等の導電物質を弾性ゴム材に混合して一体成形し、異方導電性を付与した感圧可変抵抗器を提案するものである。

【0007】

【作用】弾性ゴム材の中へ混入された炭素粉末等の導電物質は、通常の状態では導電物質間の接触圧が低く、電気的に高抵抗となっている。この弾性ゴム材の両面に圧力を加えると、弾性ゴム材が応力によって変形し、応力方向の導電物質間の接触圧が高くなり、抵抗値が減少して応力の方向に導電可能な異方性の導電作用が表われる。抵抗値は応力に対してほぼ比例的に変化するので、荷重応力の変化を抵抗値の変化として捉えることが容易に行える。

【0008】

【実施例】以下、この発明の一実施例を図に従って詳述する。図1は、シリコンゴム等の弾性ゴム材にカーボンブラックやグラファイト等の炭素粉末を混合して適宜な厚さのゴム板として成形した感圧可変抵抗器1である。図2に示すように、感圧可変抵抗器1の両面に電源2の電極3，4を接続し、感圧可変抵抗器1の両面に応力を作用させると、応力方向の炭素粉末間の接触状態が変化し、矢印で示す異方性の導電作用が表われる。

【0009】図3は、応力Fと抵抗値Rとの関係を示し、無応力状態では高抵抗であり、圧力が大きくなるに従って炭素粉末の応力方向の接触状態が密になり低抵抗へと変化する。従って、電極3，4間の電圧を測定することにより、応力を電気量に変換して表わすことができ、荷重計等に利用することができる。尚、感圧可変抵抗器1の体積や断面の縦横比、硬度、炭素系粉末の混合比によって種々の抵抗値範囲及び負荷電力の抵抗器を提供できる。

【0010】図4は感圧可変抵抗器1をスイッチ5に応用した例を示し、ラバーキートップ6の可動接点に感圧可変抵抗器1を使用している。感圧可変抵抗器1とラバーキートップ6との間には導電層7が設けられている。導電層7は感圧可変抵抗器1の一面に印刷若しくは一体成形等の手段によって形成する。ラバーキートップ6を押下げると、図5に示すように回路基板8上に配設された二つの固定接点9，10に感圧可変抵抗器1が接触し、感圧可変抵抗器1の異方性導電路a，bと、その上部の導電層7を介して二つの固定接点9，10間に回路が形成されるが、接触圧が低い状態では、感圧可変抵抗器1の抵抗値が高く、ラバーキートップ6を更に押圧して接触圧を高くするに伴って抵抗値が低下する。

【0011】例えば、このスイッチ5を発振回路の構成素子として使用すれば、押圧力によって発振周波数を任意に制御することができる。従って、コンピュータのキーボードのスクロールキーやカーソル移動キー等にこのスイッチ5を使用し、抵抗値によってスクロール速度やカーソル移動速度が変化するようにハードウエア及びソフトウエアを対応させておけば、操作者の意志に応じてスクロール速度、カーソル移動速度、コンピュータゲームにおけるキャラクターの反応速度等を自在に制御することができる。

【0012】尚、この発明は上記一実施例に限定するものではなく、この発明の精神を逸脱しない限り種々の改変を為すことができ、この発明がそれらの改変されたものに及ぶことは当然である。

【0013】

【発明の効果】この発明の感圧可変抵抗器は、上記一実施例に於て詳述したように、押圧力によって抵抗値を可変できるソリッド抵抗器であるので、断線等の故障発生が殆どなく、生産性にすぐれており、低コストで大量生

産できる。そして、摺動子をもたないソリッド形なのでキーボードやコントローラ等への適用が容易であり、可変抵抗器の応用範囲が拡大されて、種々のエレクトロニクス機器の機能向上に寄与できる。

【図面の簡単な説明】

【図１】本発明の感圧可変抵抗器の正面図。

【図２】感圧可変抵抗器の作用を示す解説図。

【図３】応力と本発明の感圧可変抵抗器の抵抗値との関係を表わす解説グラフ。

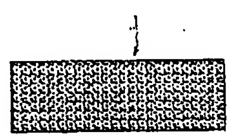
【図４】感圧可変抵抗器を使用したスイッチの断面図。

【図５】図４のスイッチのオン状態における電流経路を示す解説図。

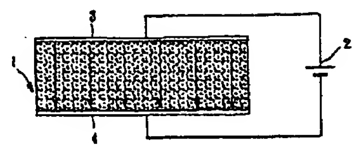
【符号の説明】

1	感圧可変抵抗器
2	電源
3，4	電極
5	スイッチ
6	ラバーキートップ
7	導電層
8	回路基板
9，10	固定接点

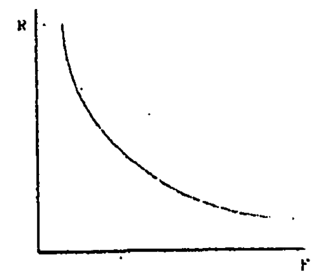
【図１】



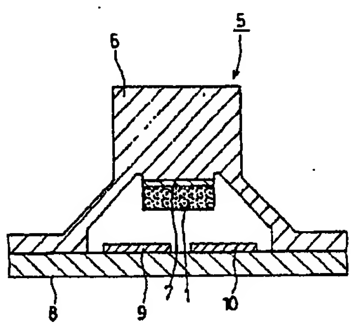
【図２】



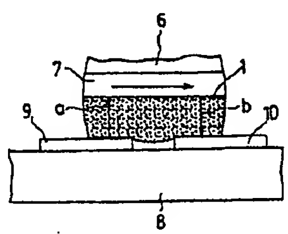
【図３】



【図４】



【図５】



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9/04	101	9009-2F		

Examination Apply No Number of claims 1 (total 3 pages)

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(54) [Title of the invention] Pressure-sensitive variable resistor

(57) [Abstract]

[Objective] To provide a variable resistor that can easily be applied to keyboards and the like.

[Construction] A pressure-sensitive variable resistor 1 is formed by mixing carbon powder such as carbon black and graphite with a silicon rubber material and integrally molding it. For applying it, for example, to a switch 5, a pressure-sensitive variable resistor 1 is provided on the bottom surface of a key top 6 via an electro-conductive layer 7. When the key top 6 is pressed down, the pressure-sensitive variable resistor 1 abuts secure contact points 9 and 10. The contact pressure between carbon powder particles is increased by the applied pressure and anisotropic conductivity is established between the secure contact points 9 and 10 and the electro-conductive layer 7. The resistance of the pressure-sensitive variable resistor 1 is changed according to the applied pressure so that the voltage between the secure contact points 9 and 10 can be manually and arbitrarily controlled.

[Claim]

[Claim 1] A pressure-sensitive variable resistor formed by mixing an electro-conductive material with an elastic rubber material and integrally molding it for anisotropic conductivity.

[Detailed explanation of the invention]

[0001]

[Scope of the invention]

The present invention relates to a variable resistor, and in particular to a variable resistor having a solid structure.

[0002]

[Prior art technology]

Traditionally, variable resistors comprising a resistor and sliding contact points are used for circuit voltage adjustment. On the other hand, sensors such as straight gauges using the properties of semiconductor pressure-sensitive elements having stress related variable electric resistance are well known.

[0003]

[Problems overcome by the invention]

For example, cursor motion keys and scroll keys in computers and power window switches in automobiles are switches that simply switch between ON and OFF. If these keys and switches are provided with a function to adjust the analogue operation rate according to the intention of the operator, improvement in terms of so-called man-machine performance is anticipated.

[0004]

In order to realize this analogue operation, a variable resistor as an electric rate operating means should be installed in keys or switches while, needless to say, hardware and software must be modified. However, there are problems with volume, weight, durability, and cost in applying the prior art variable resistors to these keys and switches. For

example, when prior art mechanical variable resistors are used in the keys of a keyboard, problems occur with space, durability, and operability.

[0005]

Therefore, the purpose of the present invention is to provide a variable resistor having a simple structure and high durability, yielding changes in resistance corresponding to operational feeling, and requiring low cost for improved functions of electronic devices.

[0006]

[Problem resolution means]

In order to achieve the above purpose, the present invention proposes a pressure-sensitive variable resistor formed by mixing an electro-conductive material such as carbon powder with an elastic rubber material and integrally molding it for anisotropic conductivity.

[0007]

[Efficacy]

An electro-conductive substance such as carbon powder mixed in the elastic rubber material normally exhibits low contact pressure between the electro-conductive substances, yielding high electric resistance. When the elastic rubber is pressured on both sides, the elastic rubber is deformed by the stress and has increased contact pressure between the electro-conductive substances in the stress direction, decreasing the resistance and establishing anisotropic conductivity in the stress direction. The resistance is changed in proportion to the stress. The change in load stress is easily translated to the change in resistance.

[0008]

[Embodiment]

An embodiment of the present invention is described in detail hereafter with reference to the drawings. Fig.1 shows a pressure-sensitive variable resistor 1 formed by mixing an elastic rubber material such as silicon rubber with carbon powder such as carbon black and graphite and molding it into a rubber plate having appropriate thickness. As shown in Fig.2, electrodes 3 and 4 of a power source 2 are connected to the pressure-sensitive variable resistor 1 on either side. Then, stress is applied to either side of the pressure-sensitive variable resistor 1. Consequently, the contact mode of the carbon powder in the stress direction is changed and anisotropic conductivity in the arrowed direction is established.

[0009]

Fig.3 shows the relationship between stress F and resistance R. The resistance is high in the absence of stress. As the pressure is increased, the carbon powder becomes a denser contact mode in the stress direction, resulting in decreased resistance. Therefore, measurements of the voltage between the electrodes 3 and 4 provide the stress expressed in electrical quantity, which can be used, for example, in load meters. Resistors having different ranges of resistance and load power can be provided depending on the volume, cross-sectional aspect ratio, hardness, and carbon powder mixing rate of the pressure-sensitive variable resistor 1.

[0010]

Fig. 4 shows an embodiment in which the pressure-sensitive variable resistor 1 is applied to a switch 5. Here, the pressure-sensitive variable resistor 1 is used as the movable contact point of a rubber key top 6. An electro-conductive layer 7 is provided between the pressure-sensitive variable resistor 1 and the rubber key top 6. The electro-conductive layer 7 is formed on one surface of the pressure-sensitive variable resistor 1 by printing or integral molding. When the rubber key top 6 is pressed down, the pressure-sensitive variable resistor 1 makes contact with two secure contact points 9 and 10 on a circuit board 8 as shown in Fig.5, establishing a circuit between the two secure contact points 9 and 10 via anisotropic electro-conductive paths a and b of the pressure-sensitive variable resistor 1 and the electro-conductive layer 7 above it. When the contact pressure is low,

the pressure-sensitive variable resistor 1 has high resistance. The resistance is reduced as the rubber key top 6 is further pressed down and the contact pressure is increased..

[0011]

For example, when the switch 5 is used as a component in an oscillation circuit, the oscillation frequency can be controlled depending on the pressing force. When the switch 5 is used in the scroll keys and cursor motion keys of a computer keyboard and the hardware and software is modified to change the scroll rate and cursor moving speed according to the resistance, the scroll rate, cursor moving speed, and character reaction speed in computer games can be fully controlled according the intention of the user.

[0012]

The present invention is not restricted to the above embodiment and various modifications can be made without departing from the scope of the invention. Needless to say, the present invention contains all such modifications.

[0013]

[Efficacy of the invention]

The pressure-sensitive variable resistor of the present invention is, as described in detail with regard to the above embodiment, a solid resistor that has a variable resistance according to the pressing force, which is subject to very little failures such as breaking, is excellent in productivity, and suitable for mass-production with low cost. It is a solid-type without a sliding element. Therefore, the pressure-sensitive variable resistor of the present invention can be easily applied to keyboards and controllers and contributes to extended use of variable resistors and, subsequently, improved functions of various electronic devices.

[Brief explanation of the drawings]

[Fig.1] A plane view of the pressure-sensitive variable resistor of the present invention.
[Fig.2] An illustration to explain the behavior of the pressure-sensitive variable resistor.
[Fig.3] A graphical representation showing the relationship between stress and resistance of the pressure-sensitive variable resistor of the present invention.
[Fig.4] A cross-sectional view of a switch using the pressure-sensitive variable resistor.
[Fig.5] An illustration showing the electric path within the switch in Fig.4 when it is on.

[Legend]

1	pressure-sensitive variable resistor
2	power source
3,4	electrode
5	switch
6	rubber key top
7	electro-conductive layer
8	circuit board
9, 10	secure contact point

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25401, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Patent Application H05-326217;
"Pressure-sensitive variable resistor"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

September 26, 2006

⑲日本国特許庁（ＪＰ）　⑪実用新案出願公告

⑫実用新案公報（Ｙ２）　平1－40545

⑸Int. Cl.⁴　識別記号　庁内整理番号　⑳⑷公告　平成１年(1989)12月４日
A 63 F 9/22　F－8403－2C

（全３頁）

⑸考案の名称　感圧導電ゴムスイッチを備えたゲームコントロール装置

㉑実　願　昭60－172995　⑯公　開　昭62－82090
㉒出　願　昭60(1985)11月12日　⑬昭62(1987)５月26日

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審　査　官　神　悦　彦

⑯参 考 文 献　実公　昭53－28325（ＪＰ，Ｙ２）

1　2

⑰実用新案登録請求の範囲

パーソナルコンピュータ用のゲームコントロール装置において、前記ゲームコントロール装置のスイッチに、押圧力によつて抵抗値が変化する感圧導電ゴムを使用し、この感圧導電ゴムスイッチに可変周波数型の発振回路を接続すると共に、この発振回路により制御される出力回路を設けたことを特徴とする感圧導電ゴムスイッチを備えたゲームコントロール装置。

考案の詳細な説明

〔産業上の利用分野〕

この考案は、押圧力によつて抵抗値が変化する感圧導電ゴムスイッチを備えたゲームコントロール装置に係わり、更に詳しくはパーソナルコンピュータやゲーム用コンピュータ等のゲームコントロールに係わる装置のスイッチを、その押圧力によつてコンピュータに送る信号の開閉周期を自在に制御出来るようにしたゲームコントロール装置に関するものである。

〔従来技術〕

従来、例えばコンピュータ用ゲームコントローラーは、１個又は２個のON／OFFスイッチと、２組の可変抵抗器によつて構成され、可変抵抗器の出力はカーソルの移動等に用いられ、ON／OFFスイッチの信号はTVゲームのミサイル、ピストルの発射等に用いられている。

このON／OFFスイッチは１回押すと１回ONするだけなので、機能が単純であり、ミサイルを連射したいときなどは、不都合であつた。

〔考案の目的〕

この考案は、かかる従来の問題点に着目して案出されたもので、その目的とするところは、コンピュータ用ゲームコントローラーのスイッチを感圧導電ゴムスイッチと可変周波数発振器を用いて出力回路を任意の周期で開閉できるようにすることで、ゲームの面白味を増すことができるようにした感圧導電ゴムスイッチを備えたゲームコントロール装置を提供するものである。

〔考案の構成〕

この考案は、上記目的を達成するためパーソナルコンピュータ用のゲームコントロール装置において、前記ゲームコントロール装置のスイッチに、押圧力によつて抵抗値が変化する感圧導電ゴムを使用し、この感圧導電ゴムスイッチに可変周波数型の発振回路を接続すると共に、この発振回路により制御される出力回路を設けたことを要旨とするものである。

〔考案の実施例〕

以下添付図面に基づき、この考案の実施例を説明する。

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第1図はこの考案の回路図の一例を示し、1は抵抗、2はコンデンサー、3は押圧力によつて抵抗値が変化する感圧導電ゴム（例えば特公昭56−9187号公報、特公昭56−54019号公報）を用いたスイッチ、4はNAND回路等のICであつて、これらの各構成要素により可変周波数型の発振回路10を構成している。また、5はリレー駆動用トランジスタ、6は前記可変周波数型の発振回路10により制御されるリレー（出力回路）である。

そして、前記可変周波数型の発振回路10の発振周波数は、感圧導電ゴムスイッチ3の抵抗値とコンデンサー2の容量によつて決定される。

前記、発振回路10からの出力はトランジスタ5をスイッチさせ、リレー6が駆動される。

したがつて、感圧導電ゴムスイッチ3の抵抗を押圧によつて変化させれば、前記発振回路10の発振周波数が変化し、リレーの開閉周期を任意に調節することができる。

次に、第2図はこの考案のブロック図でありAは発振回路、Bは信号出力を働かせる為のドライブ回路、Cはドライブ回路Bによつて動作されるリレー等の出力回路であり、ここよりの信号がコンピユータ等に送られる。

従つて、このリレー6の開閉をゲームコントローラーのスイッチとして使用すれば、コンピユータによる開閉信号の周期を使用者が任意に制御できるようになる。

第3図に、この考案の実施例を実際にゲームコントローラーのスイッチとして使用している場合の構成図の一例を示し、ゲームコントローラー11の把持部12に、前記感圧導電ゴムスイッチ部3、発振回路10、リレー6を組み込み、コンピユータ13等に接続して、前述した操作を行うようにしたものである。

〔考案の効果〕

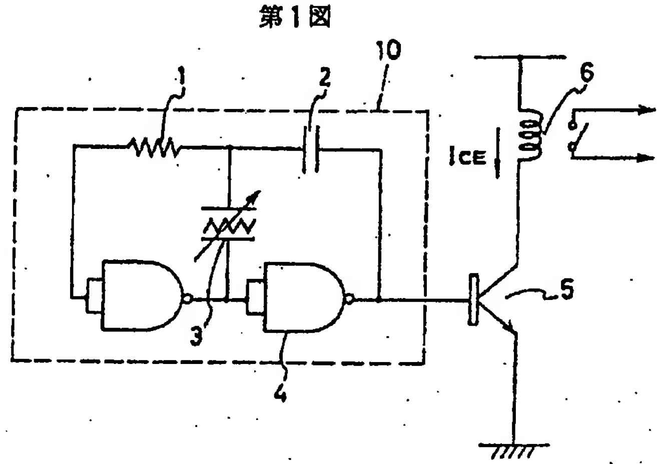
この考案は、上記のようにパーソナルコンピユータ用のゲームコントロール装置において、前記ゲームコントロール装置のスイッチに、押圧力によつて抵抗値が変化する感圧導電ゴムを使用し、この感圧導電ゴムスイッチに可変周波数型の発振回路を接続すると共に、この発振回路により制御される出力回路を設けたため、ゲームコントローラーのスイッチ信号の開閉周期の使用者の指先による押圧で自由に制御できるので、コンピユーターゲーム等を行なう上で新しい手法を使えるようになり、ゲームの面白味を増すことができる。又、新しいコントローラーが出現することで、新しいソフトウエアの開発も可能となる。

図面の簡単な説明

第1図はこの考案を実施した制御回路図、第2図はこの考案のブロック図、第3図はこの考案をゲームコントロール装置に把持部に実施した概略構成図である。

3……感圧導電ゴムスイッチ、6……リレー（出力回路）、10……発振回路、11……ゲームコントローラー。

第1図



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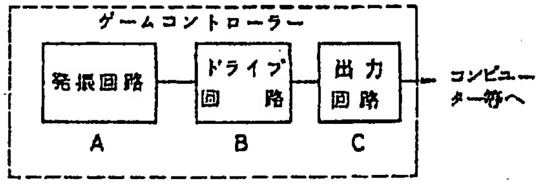
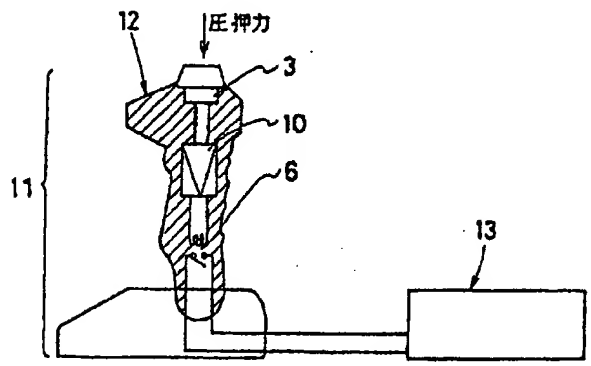
第2図



第3図



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(51) Int. Cl.[4]	Identification Symbol	JPO File No.	(24)(44) Publication December 4, 1989
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(54) Title of the Device Game control device equipped with pressure sensitive conductive rubber switch

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(22) Filing Date: November 12, 1985 (43) S62 May 26, 1987

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Examiner Nobuhiko KAMI

(56) Reference Literature Utility Model Publication S53-28325 (JP, Y2)

1

[57] Scope of Registered Utility Model Claims

A game control device for a personal computer equipped with a pressure sensitive conductive rubber switch, wherein a pressure sensitive rubber is used whose resistance value changes with the pressing force on the switch of the above game control device and an output circuit is provided which, along with connecting a variable frequency oscillation circuit to this pressure sensitive conductive rubber, is controlled by this oscillation circuit.

Detailed Description of the Device

[Industrial Field of Application]

This device pertains to a game control device equipped with a pressure sensitive conductive rubber switch whose resistance value changes with pressing force, and more particularly, relates to game control device that enables a switch in a device for game control in personal computers or game computers to freely control the opening and closing cycle of signals sent to the computer by that pressing force.

[Prior Art]

In the past, for example, a computer game controller would consist of one or two On/Off switches and two groups of variable resistors, with the output of the variable resistors being used for cursor movements and the signals of the On/Off switch being used in the firing of missiles or pistols in a TV game.

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The functions of this On/Off switch were simplistic because it would turn on only once if pressed once, and it was a drawback when someone wanted to launch a missile.

[Purpose of the Device]

Because it was conceived with a focus on such existing problems, an object of this device is to provide a game control device equipped with a pressure sensitive conductive rubber switch that is able to elevate the appeal of the game by designing a switch for a computer game controller so that it is capable of opening and closing an output circuit with a given frequency by utilizing a variable frequency oscillation circuit with pressure sensitive conductive rubber.

[Constitution of the Device]

This device, in a game control device used in a personal computer for achieving the aforementioned object, is one whose essential element consists of using pressure sensitive rubber whose resistance value changes with the pressing force on the switch of the above game control device and equipping it with an output circuit which, along with connecting a variable frequency oscillation circuit to this pressure sensitive conductive rubber, is controlled by this oscillation circuit.

[Embodiment of the Device]

We will explain an embodiment of this device on the basis of the attached drawings below.

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Fig. 1 shows an example of the circuit diagram for this device, in which 1 is a resistor, 2 is a capacitor, 3 is a switch using pressure sensitive conductive rubber (as in, for example, Published Examined Application No. S56-9187 or Published Examined Application No. S56-54019) whose resistance changes with pressing force, 4 is an IC such as a NAND circuit, and variable frequency oscillation circuit 10 is constituted by each of these elements. In addition, 5 is a relay drive transistor and 6 is a relay (in the output circuit) controlled by the above variable frequency oscillation circuit 10 (output circuit).

The oscillation frequency of the above variable frequency oscillation circuit 10 is then determined by the resistance value of the pressure sensitive conductive rubber switch 3 and the capacity of capacitor 2.

As described above, the output from the above oscillation circuit 10 is switched by transistor 5, and relay 6 is driven.

Accordingly, if the resistance of the pressure sensitive conductive rubber switch 3 is changed by the pressing force, the oscillation frequency of oscillation circuit 10 changes and the opening and closing cycle of the relay can be adjusted at will.

Next, Fig. 2 is a block figure of this device in which A is an oscillation circuit, B is the drive circuit for controlling the signal output, and C is an output circuit such as a relay that is operated by the drive circuit B and signals from here are transmitted to the computer.

Thus, if the opening and closing of this relay 6 is used for the game controller switch, the user will be able to control the cycle of opening and closing signals via the computer at will.

In Fig. 3, we illustrate an example of a structural diagram

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when the embodiment of this device is used as an actual game controller switch. Here, pressure sensitive conductive rubber switch 3, oscillation circuit 10, and a relay 6 are incorporated into the casing 12 of game controller 1 and are connected to computer 13 to perform the above operations.

[Effect of the Device]

Because this device utilizes a pressure sensitive conductive rubber whose resistance value changes with pressing force in a game control device for a personal computer and is provided with an output circuit which, along with connecting a variable frequency oscillation circuit to this pressure sensitive conductive rubber, is controlled by this oscillation circuit in the manner described above, the opening and closing cycle of the switch signal of a game controller can be freely controlled by pressing force from the finger of the user, so it will allow the use of new techniques in playing computer games and elevate the appeal of the games. Additionally, with the development of a new controller, the development of new software will also become possible.

Brief Explanation of Drawings

Fig. 1 is a control circuit diagram in which this device has been implemented, Fig. 2 is a block diagram of this device, and Fig. 3 is an outline configuration diagram in which this device is implemented in the casing on a game control device.

3..........pressure sensitive conductive rubber switch; 6.......relay (output circuit); 10..........oscillation circuit; 11..........game controller.

Fig. 1

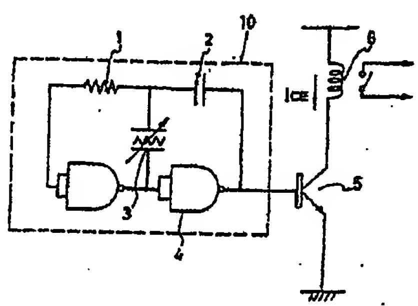
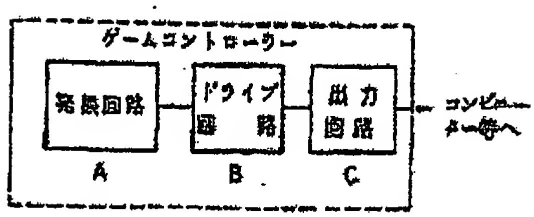


Fig. 2



[Callouts:]

[top middle] Game controller

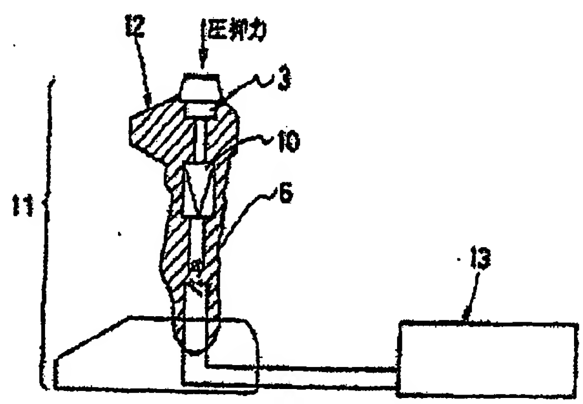
A – Oscillation circuit

B – Drive circuit

C – Output circuit

[right] To computers

Fig. 3



[Callouts:]

[top] Pressing force

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Sr. Translation Project Manager	November 27, 2006
Title	Date

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特開平7－112073

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G06F 3/02	E			

審査請求 有　請求項の数4　OL　(全6頁)

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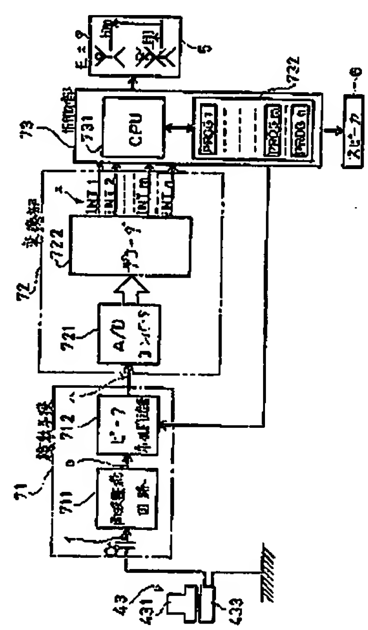
(54)【発明の名称】 テレビゲーム機

(57)【要約】

【目的】 操作部の小型化と部品点数の軽減を図ると共に、キャラクタに所望の量だけ動作変化を付与できる操作性の良いテレビゲーム機を提供する。

【構成】 遊技者が操作する押圧部材431、押圧力の強さをレベル電圧に変換する圧電素子433、このレベル電圧から電圧レベル等を検出する検出手段71、この電圧のレベルに応じて対応付けられたINT信号を出力する変換部72、このINT信号にそれぞれ対応付けられた量の動作変化をキャラクタに行なわせる制御部73、及び制御部73の画像信号によりゲーム画面を表示するモニタ5を備える構成とした。



【特許請求の範囲】

【請求項1】 本体操作面に押圧操作可能に設けられ、押圧に応じて表示画面上のキャラクタに動作変化を与えるテレビゲーム機において、押圧操作に応じて変位する押圧部材と、上記押圧部材へ付与される殴打力に対応したレベル電圧を発生する圧電素子と、上記圧電素子の発生電圧から、操作タイミングと電圧レベルを検出する検出手段と、上記検出手段からの操作タイミングに同期して上記キャラクタに動作変化を与えるとともに、上記電圧レベルに応じて上記動作変化の量を変更する動作制御手段とを備えたことを特徴とするテレビゲーム機。

【請求項2】 上記圧電素子は、上記本体内であって、上記押圧部材の変位範囲内に固設されることを特徴とする請求項1記載のテレビゲーム機。

【請求項3】 請求項2記載のテレビゲーム機において、流体が封入された袋体からなる押圧力伝達部材が、上記圧電素子と上記押圧部材との間に介設されることを特徴とするテレビゲーム機。

【請求項4】 上記動作制御手段は、キャラクタの動作中、上記検出手段へ禁止信号を出力し、上記検出手段はこの禁止信号が出力されている間、電圧レベルの検出動作を行なわないことを特徴とする請求項1，2、または3記載のテレビゲーム機。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、遊技者の操作に応じてキャラクタに移動やシューティング等の動作に変化を与えるテレビゲーム機に関するものである。

【0002】

【従来の技術】従来のテレビゲーム機において、通常、1回の操作で動作させられるキャラクタの動作量は一定の場合が多かった。そのため、動作量を変化させることが必要な場合、スイッチの押圧時間の長さを変える、あるいは予め動作量が設定されているスイッチを複数個取り付け、どれかのスイッチを選択して押すことによって動作量が変更されるような制御形式が採用されていた。

【0003】

【発明が解決しようとする課題】キャラクタのある動作の変化量を複数のスイッチで変更する上記のような制御形式においては、スイッチが装着される操作部取付スペースを大きくすることが必要となる。また、上記の制御形式においては、動作量を変更するのにスイッチの押圧時間を長い目にする、あるいは所望の動作量に設定されたスイッチを選択して押すなどの操作が必要となるため、余計な時間が掛かってキャラクタの素早い動作に合わせて好適なタイミングで操作することが困難であった。

【0004】本発明は、上記のような問題点に鑑みてなされたものであり、上記操作部の小型化と部品点数の軽減を図ると共に、キャラクタに好適なタイミングで所望量だけ動作変化を与えることができる操作性の良いテレビゲーム機の提供を目的としている。

【0005】

【課題を解決するための手段】請求項1記載の発明は、本体操作面に押圧操作可能に設けられ、押圧に応じて表示画面上のキャラクタに動作変化を与えるテレビゲーム機において、押圧操作に応じて変位する押圧部材と、上記押圧部材へ付与される殴打力に対応したレベル電圧を発生する圧電素子と、上記圧電素子の発生電圧から、操作タイミングと電圧レベルを検出する検出手段と、上記検出手段からの操作タイミングに同期して上記キャラクタに動作変化を与えるとともに、上記電圧レベルに応じて上記動作変化の量を変更する動作制御手段とを備える構成とした。

【0006】請求項2記載の発明は、上記圧電素子が上記本体内であって、上記押圧部材の変位範囲内に固設される構成とした。

【0007】請求項3記載の発明は、流体が封入された袋体からなる押圧力伝達部材が、上記圧電素子と上記押圧部材との間に介設される構成とした。

【0008】請求項4記載の発明は、上記動作制御手段が、キャラクタの動作中、上記検出手段へ禁止信号を出力し、上記検出手段はこの禁止信号が出力されている間、電圧レベルの検出動作を行なわない構成とした。

【0009】

【作用】請求項1記載の発明によれば、押圧部材が押圧されると、圧電素子がこの押圧力に応じてレベル電圧を発生し、検出手段がこのレベル電圧から電圧レベル等を検出するため、動作制御手段はこの電圧レベルに応じた量でキャラクタを動作させる。

【0010】請求項2記載の発明によれば、押圧力により押圧部材が変位されて圧電素子に当接し、この圧電素子には押圧力が付与される。

【0011】請求項3記載の発明によれば、押圧力により押圧部材が変位されると、この押圧力が押圧力伝達部材によって多少緩和されて圧電素子に付与される。

【0012】請求項4記載の発明によれば、キャラクタの動作中には動作制御手段が禁止信号を出力するため、検出手段はレベル信号の検出動作を行なわない。

【0013】

【実施例】図4は、本発明に係るテレビゲーム機の概観図である。このテレビゲーム機1は、本体2に、コインを投入する投入口3、各種操作部が取り付けられる中央前部の操作パネル部4、ゲーム画面を表示するモニタ5、ゲーム状況に応じて効果音を発するスピーカ6等を備えている。上記操作パネル部4には、ゲームを開始するスタートボタン41、キャラクタの移動方向を選択するレバースイッチ部42、及び遊技者が押してキャラクタにゲーム内容に応じた、例えば移動、ジャンプ、シュート、射撃等の動作を行なわせる上記押ボタンスイッチ

部43が設けられている。

【0014】図1は、上記テレビゲーム機1のブロック構成を示すものである。このテレビゲーム機1は、遊技者によって押圧操作され、その押圧力に対応したレベルの電圧を発生する押ボタンスイッチ部43、このレベル電圧を波形整形する検出手段71、波形整形されたアナログの信号を後述するINT信号に変換する変換部72、このINT信号と同期し、かつ対応した移動等の動作変更をモニタ5上のキャラクタに行なわせる制御部73を備え、この変換部72と制御部73とで前記動作制御手段が構成されている。

【0015】上記押ボタンスイッチ部43は、図2に示すように、操作パネル部4を支持する本体2の操作支持部21に形成された取付口211に嵌挿される筒状本体430と、この筒状本体430内に遊技者により殴打乃至押圧され、操作パネル4に対して出没可能に装着された押圧部材431、この押圧部材431に付与された押圧力を多少緩和させる押圧力伝達部材432、この押圧力伝達部材432から付与される押圧力に対応したレベル電圧を発生する圧電素子433、及び操作される前の初期位置に向けて押圧部材431を付勢するコイルスプリング434が設けられている。

【0016】上記押圧部材431は柱状部材からなり、頭部431aとその下部周縁の鍔部431bとからなっており、筒状本体430から抜けないようにしてある。押圧力伝達部材432は、液体や空気等の気体を合成樹脂等からなる柱状の袋体内に封入されているもので鍔部431bの下面に取り付けられ、この押圧力伝達部材432に上記コイルスプリング434が遊嵌されている。

【0017】上記筒状本体430にはその上端に口部430a、中間位置に押圧部材431の押し込み量を図2の一点鎖線で示す位置に規制する規制部430b、及び下端の圧電素子433の直ぐ上部にコイルスプリング434の抜けを防止する当接部430cが内面に突出して形成されている。

【0018】上記圧電素子433は平板形状を有し、その両面に電極433a，433bを形成してなるものである。この圧電素子433は、筒状本体430の底面430dにおいて上記押圧力伝達部材432と対向する位置に多少の間隙を有し、あるいは接した状態で固定され、上記電極433a，433bにはそれぞれ信号線が接続され、両電極433a、433b間に発生した電圧を検出手段71に送出し得るようになっている。このように構成することで、押圧部材431への押圧力により押圧力伝達部材432が下降して、その下端面が圧電素子433の上面に当接（あるいは衝突）すると、このときの押圧力に対応したレベルの電圧が両電極433a，433b間に取り出されるようになっている。なお、圧電素子433からのレベル電圧は、圧電素子433の振動と残響により発生する交流信号である。

【0019】上記検出手段71は、両波整流回路711とピークホールド回路712とを備え、圧電素子433のレベル電圧の信号がカップリングコンデンサCcを介して両波整流回路711に入力されるようになっている。カップリングコンデンサCcは、入力側の直流成分をカットするもので、これにより両波整流回路711には上記押圧力に対応したレベルの電圧成分のみが入力されるようになっている。両波整流回路711はダイオードブリッジ、またはオペアンプ等からなり、入力電圧信号を整流して直流信号に変換するものである。

【0020】ピークホールド回路712は、レベル電圧の信号から最大レベルとなるピーク値をホールドするものである。

【0021】変換部72は、A／Dコンバータ721とデコーダ722とを備えている。このA／Dコンバータ721はアナログ信号をディジタル信号に変換するもので、上記のホールドされたピーク電圧をディジタル値に変換して出力するようになっている。

【0022】デコーダ722は、変換された上記ディジタル値をn段階に分割（デコード）し、この各段階に対応付けられたINT信号を制御部73に出力するものである。

【0023】上記制御部73は、ゲームプログラムやゲームのスコア等を記憶するROM、RAMを備え、ゲーム展開を制御するマイクロコンピュータ（以下CPUという）731と、割込みにより読み出される各サブルーチンプログラムPROG1～PROGnを記憶するROM732を有している。これらのサブルーチンプログラムPROG1～PROGnは、モニタ5上の表示キャラクタの移動等、所定の動作変化量を制御するもので、上記の各INT信号にそれぞれ対応付けられている。

【0024】また、制御部73は、サブルーチンプログラムPROG1～PROGnのいずれかが選定された場合、そのプログラム内容に基づいて画像信号を生成すると共に、サブルーチンプログラムPROG1～PROGnの実行中は、検出動作を禁止する禁止信号を上記ピークホールド回路712に出力するようになっている。これにより、サブルーチンプログラムPROG1～PROGnの処理の実行中には、ピークホールド回路712の動作を禁止し、その間に入力される次の押圧操作によるレベル電圧の信号を受け付けないようになっている。更に、この制御部73はゲーム状況に応じてスピーカ6に効果音信号を出力する。

【0025】次に、本発明に係るテレビゲーム機1でバスケットボールゲームを行なった場合の作用を図1，2，3，4に基づいて説明する。なお、図3は主要部の信号を示すタイムチャートである。この場合、レバースイッチ部42は、プレーヤー（キャラクタ）を水平方向に移動させ、押ボタンスイッチ部43は垂直方向に移動、即ちジャンプを行なわせるものとし、またサブルー

チンプログラムPROG1～PROGnは、INT信号を介して大きな値のレベル領域に対応付けられているものほど、大きなジャンプ量となるように予め設定しておく。

【0026】まず、遊技者がコインを投入口3から投入し、スタートボタン41を押すことによりゲームが開始される。遊技者が指や手で押圧部材431を強く押すと、押圧部材431はコイルスプリング434の付勢力に抗しながら図2に示す矢印F方向に移動する。その結果、押圧力伝達部材432の下面が圧電素子433を押圧することとなり、両電極433a、433b間には押圧力の強さに対応したレベル電圧の交流信号が発生する。

【0027】この交流信号はカップリングコンデンサCcを通過し、その波形が図3の（イ）に示される状態で両波整流回路711に入力され、この出力側には同図の（ロ）に示す直流信号が出力される。そして、この直流信号のピーク値Vmがピークホールド回路712によってホールドされて、同図の（ハ）に示すように電圧Vmのレベル信号（以下、ピークホールド信号という）となる。このピークホールド信号はA／Dコンバータ721によってディジタルの電圧値Vmに変換され、デコーダ722は、この電圧値Vmを区分けすることにより図3の（ニ）に示すレベル領域（1～n）のいずれに該当するかを特定すると共に、そのレベル領域に対応付けられているINT信号INTmを出力する。

【0028】制御部73は、入力されたINT信号INTmと対応付けられているサブルーチンプログラムPROGmをROM732から読み出し、このプログラムPROGmで定められた量だけプレイヤーをジャンプさせるように画像信号を生成する。モニタ5は、この画像信号により図1に示すようにプレイヤーが高さHmで高くジャンプするのを表示する。

【0029】このプレイヤーのジャンプ開始から着地までのジャンプ動作の間、制御部73は禁止信号をピークホールド回路712へ送出する。この禁止信号により、ピークホールド回路712はレベル電圧Vmの出力を中断して、次の操作による信号の入力待ちの状態となる。

【0030】次に、押圧部材431が軽く操作されると、ピークホールド回路712でホールドされるピーク値が小さい電圧値V1となり、この結果、デコーダ722から小さな電圧値に対応付けられた制御信号INT1が出力される。この場合、制御部73はこの制御信号INT1に対応付けられているサブルーチンプログラムPROG1を呼び出して画像信号を生成するため、モニタ5の画面にはプレイヤーが高さH1で小さくジャンプするのが表示される。

【0031】なお、本発明に係るテレビゲーム機は、このバスケットボールのゲームの他に、サッカーボール、ボクシング、あるいは戦闘等のゲームにも適用可能であり、この場合、押圧力を調整してシュートの強さやパンチ力を多段階に変更することが可能となる。更に、本発明に係るテレビゲーム機をシューティングテレビゲーム機に適用し、遊技者の押圧力の加減によってキャラクタの破壊力等が変更されるようにしてもよく、上記したようなスポーツ関連のテレビゲームに限られるものではない。

【0032】また、上記実施例では、圧電素子433を筒状本体430の底面430dに固定する場合を示したが、この圧電素子433を押圧部材431の下面に固定し、押圧力伝達部材432を底面430dとの間に介在させる構成としてもよい。この構成によると、遊技者が押圧部材431を押して操作を行なうと、圧電素子433は下方に移動し、押圧力伝達部材432を介して筒状本体430の底面430dに当接する。このため、圧電素子433は底面430dから押圧力伝達部材432を介して押圧力が付与され、上記実施例と同様にその電極433a，433b間にレベル電圧が取り出される。圧電素子433の取付位置をこのように設定した場合、押圧部材431と圧電素子433との間の位置合わせが不要となり、押ボタンスイッチ部43の組立が容易になる。

【0033】更に、前記の実施例では、デコーダ722が制御部73と別に設けられる構成としたが、A／Dコンバータ721のディジタルの出力信号を制御部73に直接入力し、デコーダ722の機能を制御部73内のCPU731で実現させるようにしてもよい。

【0034】なお、上記押圧力伝達部材432は押圧部材431と圧電素子433の衝突による破損等を防止するもので、適度な弾力性を有するものであればよく、ゴムや合成樹脂等の固形物でもよい。

【0035】

【発明の効果】請求項1記載の発明によれば、押圧部材の押圧力に対応したレベル電圧を発生する圧電素子を設けると共に、この圧電素子による電圧の電圧レベルに応じてキャラクタの動作変化の量を変更する構成とししたため、遊技者の押圧力で所望する動作変化をキャラクタに行なわせることができる。また、このように、ひとつの押圧部材を押圧操作するだけでキャラクタに種々の動作変化を与えることができるため、操作性を大いに向上し得ると共に、本体操作面の省スペース化が図られる。

【0036】請求項2記載の発明は、圧電素子を押圧部材の変位範囲内に固設する構成としたため、圧電素子からの信号線は移動せず、断線等の故障が抑制される。

【0037】請求項3記載の発明は、押圧部材と圧電素子との間に押圧力伝達部材を介設する構成としたため、圧電素子に作用する押圧力が多少緩和されて圧電素子の破損等が抑制される。

【0038】請求項4記載の発明は、キャラクタの動作中、検出手段が検出動作を行なわない構成であるため、

前回の押圧操作に対するキャラクタの動作変化が終了するまで次回の押圧操作を受け付けず、キャラクタの動作が正常に行なわれて遊技者に戸惑いを感じさせないテレビゲーム機とすることができる。

【図面の簡単な説明】

【図1】本発明に係るテレビゲーム機のブロック構成図である。

【図2】押ボタンスイッチ部の要部断面図である。

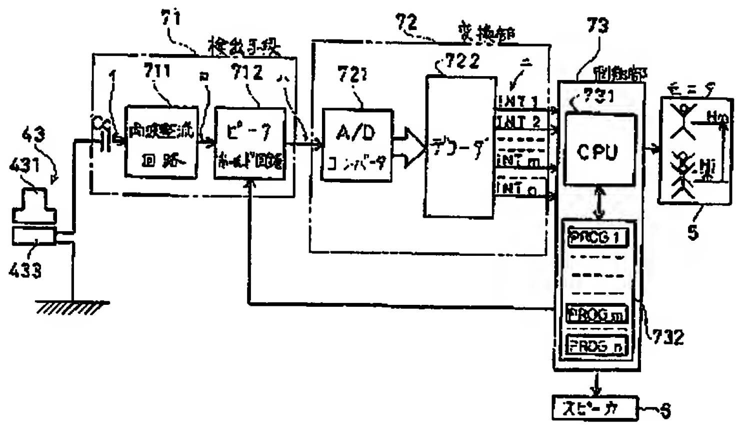
【図3】図1の各部における波形、あるいは動作説明を示すもので、(イ)は両波整流回路の入力波形、(ロ)は両波整流回路の出力波形、(ハ)はピークホールド回路の出力波形、(ニ)はデコーダの動作説明図である。

【図4】本発明に係るテレビゲーム機の概観図である。*

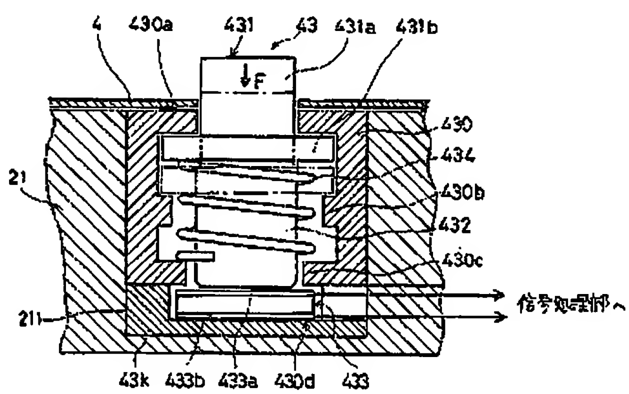
*【符号の説明】

1 テレビゲーム機
2 本体
3 投入口
4 操作パネル
5 モニタ
43 押ボタンスイッチ部
71 検出手段
72 変換部
73 制御部
431 押圧部材
433 圧電素子

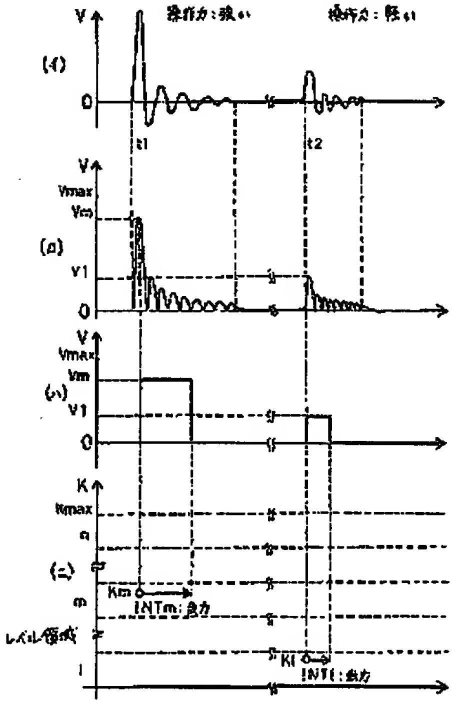
【図1】



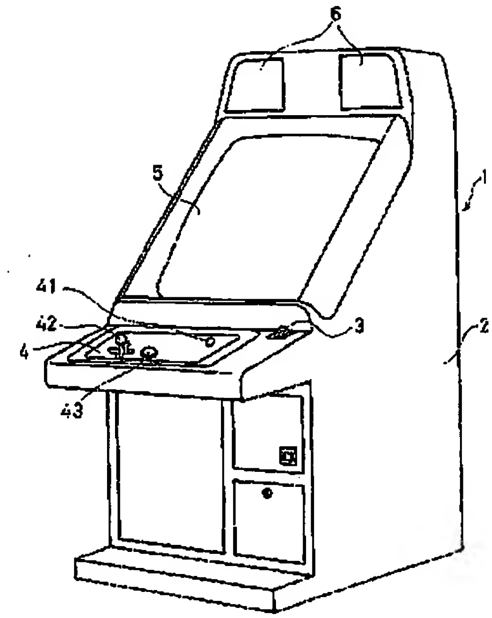
【図2】



【図3】


操作力：強い
操作力：軽い
V
(イ)
0
t1
t2
Vmax
Vm
(ロ)
V1
(ハ)
K
Kmax
n
(ニ)
m
レベル領域
l
Km
INTm：出力
Kl
INTl：出力

【図4】


6
5
1
41
42
4
43
3
2

PATENT ABSTRACTS OF JAPAN

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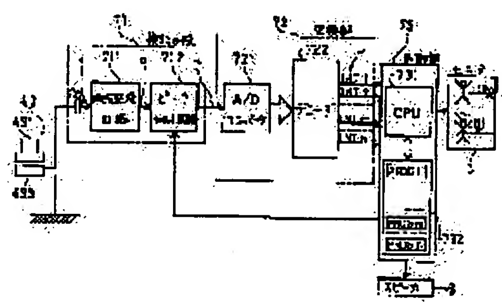
(71)Applicant : KONAMI KK
(72)Inventor : YAMAOKA SHINGO

(54) VIDEO GAME MACHINE

(57)Abstract:

PURPOSE: To provide the video game machine having satisfactory operability, which can miniaturize an operating part and can reduce the number of parts, and an operating variation also can be imparted to a character by a desired amount.



CONSTITUTION: This game machine is provided with a pressing member 431 operated by a player, a piezoelectric element 433 for converting strength of pressing force to a level voltage, a detecting means 71 for detecting a voltage level, etc., from this level voltage, a converting part 72 for outputting an INT signal allowed to correspond in accordance with a level of this voltage, a control part 73 for allowing a character to respectively execute an operating variation of the amount allowed to correspond to this INT signal, and a monitor 5 for displaying a game screen by an image signal of the control part 73.

LEGAL STATUS

[Date of request for examination] 15.10.1993

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	2524475
[Date of registration]	31.05.1996
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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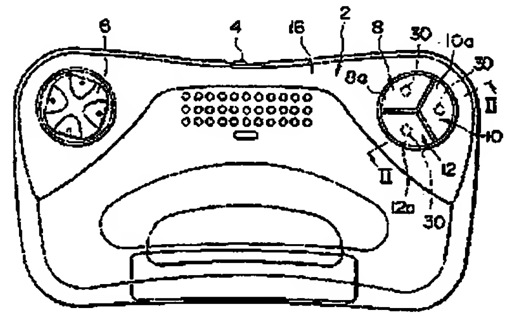
(54)【発明の名称】　ゲーム装置の操作ボタン

(57)【要約】

【目的】　複数の操作ボタンの混合組合せ操作が容易で、しかも操作盤上の占有スペースを少なくして意匠的にも良好で、かつコストの削減をも可能としたゲーム装置の操作ボタンを提供する。

【構成】　ゲーム装置の少なくとも3種類の圧電スイッチ30を操作するための各キートップ8ａ、10ａ、12ａを、操作盤2の一箇所に集中させ、かつ各キートップ8ａ、10ａ、12ａを集合状態で円形をなす分割形状に形成して隣接配置した。これにより、各キートップ8ａ、10ａ、12ａの単独操作は勿論、2種類あるいは3種類以上の混合組合せ操作が可能となる。



【特許請求の範囲】

【請求項１】 ゲーム装置の操作盤に少なくとも３種類のスイッチを備え、これら各スイッチに操作用のキートップを取り付けたゲーム装置の操作ボタンにおいて、

前記各キートップを操作盤の一箇所に集中させ，かつ各キートップを集合状態で所定形状をなす分割形状に形成して隣接配置し，各キートップを単独操作及び複数の複合組合せ操作可能としたことを特徴とするゲーム装置の操作ボタン。

【請求項２】 請求項１において、

前記各キートップは、操作盤カバーの内外に位置する隣接キートップとの接触面を，キーストロークよりも長く形成したことを特徴とするゲーム装置の操作ボタン。

【請求項３】 請求項１または請求項２において，

前記各キートップは、隣接キートップとの接触縁を除く上面外縁部に，操作盤カバーのキートップ取付孔との引掛かり防止用の曲面部を形成したことを特徴とするゲーム装置の操作ボタン。

【請求項４】 請求項１，請求項２または請求項３において，

前記各キートップの上面外縁部に、各キートップを同時に操作する指挿入部分を残し、各キートップを単独操作するための凸部を形成したことを特徴とするゲーム装置の操作ボタン。

【請求項５】 請求項１ないし請求項４のいずれかにおいて，

前記各キートップの内、操作指挿入方向手前側のキートップをスイッチ操作とは無関係のダミー用としたことを特徴とするゲーム装置の操作ボタン。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、ゲーム機、例えばテレビゲーム装置などの操作盤に取り付けられる操作ボタンに関する。

【０００２】

【従来の技術】業務用あるいは家庭用のテレビゲーム装置においては，操作盤上に各種操作を行なうための複数の操作ボタンが設けられている。

【０００３】このような操作盤上に組込まれる操作ボタンとしては、例えば電源投入用のパワーボタン，ゲーム開始用のスタートボタン，表示キャラクタなどの移動方向を指定するための方向指示用操作ボタン、各種動作遂行用の複数の機能ボタンなどがある。

【０００４】そして、これら各種の操作ボタンは操作盤上に独立して設けられ、かつ誤操作防止のためそれぞれの操作ボタンが離れた状態で設けられるのが通常である。

【０００５】

【発明が解決しようとする課題】前記従来の操作ボタンにおいては、操作ボタンを操作する際に、各操作ボタンが独立し、かつ離れているため，操作ボタンの誤操作は生じ難いが、ゲームの内容が複雑になるにつれて，各操作ボタンを単独で操作することよりも，例えば複数の機能ボタンを同時に操作したり、その同時に操作する機能ボタンの組合せが変化したり，あるいはある操作ボタンを頻繁に操作しつつ要所要所に他の操作ボタンを操作するというように，複数の操作ボタンの混合組合せ操作が必要となり、従来の独立，離間型の操作ボタンでは親指一本で複数の操作ボタンに届かなかったりして，前記複数の操作ボタンの複合組合せ操作が困難であるという問題があった。

【０００６】また、複数の操作ボタンを独立、離間させて設置すると，それだけ操作盤のスペースも必要となり，スイッチ機構も独立して必要になりコスト高になる上に，意匠的にも乱雑な感じのレイアウトになるという問題もあった。

【０００７】本発明は、前記従来の問題点を解決するためになしたもので、その目的は、複数の操作ボタンの複合組合せ操作が容易で、しかも操作盤上の占有スペースを少なくして意匠的にも良好で、かつコストの削減をも可能としたゲーム装置の操作ボタンを提供することにある。

【０００８】

【課題を解決するための手段】請求項１の発明は，ゲーム装置の操作盤に少なくとも３種類のスイッチを備え、これら各スイッチに操作用のキートップを取り付けたゲーム装置の操作ボタンにおいて、前記各キートップを操作盤の一箇所に集中させ，かつ各キートップを集合状態で所定形状をなす分割形状に形成して隣接配置し，各キートップを単独操作及び複数の複合組合せ操作可能としたことを特徴としている。

【０００９】請求項２の発明は、請求項１において、前記各キートップは、操作盤カバーの内外に位置する隣接キートップとの接触面を，キーストロークよりも長く形成したことを特徴としている。

【００１０】請求項３の発明は、請求項１または請求項２において、前記各キートップは，隣接キートップとの接触縁を除く上面外縁部に，操作盤カバーのキートップ取付孔との引掛かり防止用の曲面部を形成したことを特徴としている。

【００１１】請求項４の発明は、請求項１、請求項２または請求項３において、前記各キートップの上面外縁部に，各キートップを同時に操作する指挿入部分を残し、各キートップを単独操作するための凸部を形成したことを特徴としている。

【００１２】請求項５の発明は、請求項１ないし請求項４のいずれかにおいて、前記各キートップの内，操作指挿入方向手前側のキートップをスイッチ操作とは無関係のダミー用としたことを特徴としている。

【００１３】

【作用】請求項１によれば、少なくとも３種類のスイッチ操作用のキートップを操作盤の一箇所に集中させ、かつ各キートップを集合状態で所定形状をなす分割形状に形成して隣接配置することにより、各キートップの単独操作は勿論のこと、２種類あるいは３種類以上のキートップを一本の指の一回の押圧動作で同時に複合して組合せ操作することが容易になしうる。

【００１４】この場合、各キートップが隣接した状態となっているため、キートップが散在している場合に比し、一度キー操作の動作をした後、操作指をニュートラル位置に戻すことが簡単に行なえ、しかもキートップが隣接しているので、操作指の腹の部分がキートップの角部に当ることが少なく、長時間の操作をする場合でも操作指が痛くなるような状態を避けることができる。

【００１５】また、操作ボタンを集中配置しているので、スイッチ機構も独立して配置した場合に比し簡略化でき、コストの削減が可能で、操作盤上のスペースも少なくて済み、意匠的にも良好となる。

【００１６】請求項２によれば、各キートップの操作盤カバーの内外に位置する隣接キートップとの接触面をキーストロークよりも長く形成することにより、各キートップが隣接して接触する状態であっても、キートップ同士が外れることなく確実な動作が期待できる。

【００１７】請求項３によれば、各キートップの隣接キートップとの接触縁を除く上面外縁部に、操作盤カバーの取付孔との引掛かり防止用の曲面部を形成することにより、各キートップのスムーズな動作を期待することができる。

【００１８】請求項４によれば、各キートップの上面外縁部に、各キートップを同時に操作する指挿入部分を残し、各キートップを単独操作するための凸部を形成することにより、各キートップの複合組合せ操作は勿論のこと、単独操作も誤操作することなく確実に操作することが可能となる。

【００１９】請求項５によれば、ダミー用のキートップをニュートラルキーとして使用することにより、より一層誤操作を防止することが可能となる。また、ダミー用のキートップにて操作指を休めることが可能となり、操作指の疲れを少なくして、長時間のゲーム操作を可能とする。

【００２０】

【実施例】以下、図面を参照しながら本発明の好適な実施例について説明する。

【００２１】図１～図３は、本発明の一実施例に係るゲーム装置の操作ボタンを示す図で、図１はその操作ボタンを備える操作盤の平面図、図２は図１のII－II線に沿う断面図、図３はキートップと圧電スイッチとの関係を示す平面図である。

【００２２】本実施例に係るゲーム装置は、操作盤２上にパワーボタン４、方向支持用操作ボタン６、スタートボタン８及び２つの機能操作ボタン１０、１２が設けられている。

【００２３】パワーボタン４及び方向支持用操作ボタン６は、操作盤２上に独立して配置されている。そして、スタートボタン８及び２つの機能操作ボタン１０、１２は、操作盤２上の図１中右上位置に集中配置されるようになっている。

【００２４】具体的には、スタートボタン８及び２つの機能操作ボタン１０、１２は、各キートップ８ａ、１０ａ、１２ａの平面形状が円を３分割した扇状に形成され、これら各キートップ８ａ、１０ａ、１２ａを操作盤２上の図１右上位置一箇所に集中させて隣接配置し、これら各キートップ８ａ、１０ａ、１２ａを集合させた状態で円形をなすように形成されている。

【００２５】また、各キートップ８ａ、１０ａ、１２ａは、下端側に係止用のフランジ１４を有し、上部を操作盤２の上部ハウジング１６に形成した取付孔１８より突出させ、フランジ１４を取付孔１８の下縁部に当接させることにより、脱落を防止するようにしている。なお、各キートップ８ａ、１０ａ、１２ａは、それぞれ隣接上側部及びフランジ１４の隣接側部に、接触面２０ａ、２０ｂを形成するようにしている。

【００２６】更に、各キートップ８ａ、１０ａ、１２ａの下側には、スイッチ部２２が配設されている。このスイッチ部２２は、操作盤２の下部ハウジング２４内に突出形成した基板保持部２６上にプリント基板２８を載置固定し、このプリント基板２８上に保持部材３２を載置固定し、さらにこの保持部材３２に圧電スイッチ３０を保持させて形成するようにしている。保持部材３２は、ゴムなどの弾性変形可能な板状のもので、この保持部材３２の各キートップ８ａ、１０ａ、１２ａ対応位置にはそれぞれキートップ８ａ、１０ａ、１２ａの下面と接触してキートップ８ａ、１０ａ、１２ａを支持する断面略コ字状の突出部３４が形成されている。そして、これら各突出部３４の中央下面にそれぞれ圧電スイッチ３０が取り付けられている。この圧電スイッチ３０は、圧縮によって導電性が生じるいわゆる圧電ゴムを使用したもので、キートップ８ａ、１０ａ、１２ａの押下により保持部材３２が変形し、圧電スイッチ３０がプリント基板２８上で押圧されて導電性が変化すると、プリント基板２８の回路にスイッチ操作信号が供給されるようになっている。

【００２７】このように、本実施例においては、各キートップ８ａ、１０ａ、１２ａを操作盤２上の図１右上位置一箇所に集中させて隣接配置することにより、操作指一本で各キートップ８ａ、１０ａ、１２ａの単独操作は勿論のこと、一本の指の一回の動作で、キートップ８ａ、１０ａ、１２ａを２つ同時あるいは３つ同時の種々の複合、組合せ操作が容易になしうることとなる。

【００２８】また、各キートップ８ａ、１０ａ、１２ａ

が隣接した状態となっているため、キートップが散在している場合に比し、一度キー操作の動作をした後、操作指をニュートラル位置に戻すことが簡単に行なえる。

【0029】更に、キートップ8a、10a、12aが隣接しているので、操作指の腹の部分がキートップ8a、10a、12aの角部に当ることが少なく、従って操作指が痛くなることが少なく、長時間の操作にも十分に耐え得る。

【0030】また、各キートップ8a、10a、12aが一箇所に集中配置されているので、操作盤2上で占めるスペースが少なくて済み、意匠的にもキートップ8a、10a、12aの集合状態で円形等の所定の形状となり良好なもので、しかもスイッチ部22の機構も一つの保持部材32に複数の圧電スイッチ30を取り付ければ済み、部品点数の省略及びコストの削減が可能となる。

【0031】図4には、本発明の他の実施例を示す。

【0032】この実施例では、各キートップ8a、10a、12aの隣接上側部及びフランジ14の隣接側部に形成した各接触面20a、20bの長さL1をキーストロークL2よりも長く形成することにより、キートップ8a、10a、12aのキー操作中に接触面20a、20bが常に接触した状態を確保し、確実な動作がなしうるようにしている。

【0033】また、各キートップ8a、10a、12aの隣接キートップとの接触縁を除く上面外縁部に、操作盤2の上部ハウジング16に形成した取付孔18との引掛かり防止用の曲面部36を形成するようにしている。この曲面部36の存在によって、たとえ図中2点鎖線に示すように、キー操作中に万が一キートップ8a、10a、12aの隣接キートップとの接触縁を除く上面外縁部が取付孔18より下方に移動した場合でも、取付孔18に引掛かることなく、確実に復元し、良好な動作状態を確保することが可能となる。

【0034】他の構成及び作用は、前記実施例と同様に付き、重複した説明を省略する。

【0035】図5には、本発明の更に他の実施例を示す。

【0036】この実施例では、同図（a）中矢印で示す操作指の挿入方向に対し、手前左右両側に2つのキートップ38、40を配し、かつその奥側に1つのキートップ42を配した合計3個のキートップを一箇所に集中させ、集合状態で略楕円形状に形成されるようになっている。

【0037】そして、同図（b）に示すように、各キートップ38、40、42の上面略中央部分に各キートップ38、40、42を2個又は3個同時に操作するための操作指の挿入部分44を残し、その外縁部に各キートップ38、40、42を単独操作するための長円状の凸部46、48、50が形成されるようになっている。

【0038】即ち、本実施例においては、各キートップ38、40、42の一般面（低い面）の高さh1に対し、奥側のキートップ42の凸部50の高さh2を若干高くし、更に手前2つのキートップ38、40の高さをh3をh2よりも高く設定するようにしている。この場合の高さの比率は、h1：h2：h3＝7：8：9になるように設定されている。

【0039】このように、高さh1よりも凸部46、48、50の高さh2、h3を高くすることで、混合操作と単独操作との誤操作を防止することができ、また凸部46、48の高さh3よりも凸部50の高さh2を低くすることで、各キートップ38、40、42の単独操作時の誤操作を防止するようにしている。特にキートップ42はポーズボタンとして用いられることが多く、そのため他の操作時に誤ってキートップ42を押し、ゲームを中断させるのを防止するようにしている。

【0040】従って、操作指の挿入部分44を用いて、複数のキートップ38、40、42を2個あるいは3個適宜の混合組合せ操作が容易になし得、しかも各キートップ38、40、42の単独操作も凸部46、48、50を用いることにより、誤操作を生じさせることなく容易かつ確実に行なうことが可能である。

【0041】他の構成及び作用は、前記各実施例と同様に付き、重複した説明を省略する。

【0042】図6には、本発明の更に他の実施例を示す。

【0043】この実施例では、平面的に円を4分割した状態の4個のキートップ52、54、56、58を、同図中矢印で示す操作指の挿入方向に対し、手前側及び奥側に2個、左右側に2個集合させて円形に配置するようにしている。

【0044】そして、奥側及び左右側の3個のキートップ54、56、58には、それぞれ圧電スイッチ30を対応させて配置し、手前側のキートップ52には圧電スイッチを配置せず、この手前側のキートップ52をスイッチ操作とは無関係のダミー用として用いるようにしている。

【0045】従って、スイッチ操作とは無関係の手前側のキートップ52をニュートラルキーとして用い、このキートップ52を中心として奥側及び左右側のキートップ54、56、58を操作し、キートップ52位置で待機するようにすれば、常に指のポジションを認識した状態でキー操作をすることができ、より一層操作性が向上し、かつ誤操作を防止することが可能となると共に、キートップ52上で待機して休めるため、指の疲れが格段に減少することとなる。

【0046】他の構成及び作用は、前記実施例と同様に付き、重複した説明を省略する。

【0047】次に、図7を参照しつつ、本発明に係るゲーム装置の操作ボタンの操作状態の一例を、独立型の操

作ボタンと比較して説明する。

【0048】図中、左側が独立型の操作ボタンの例を示しており、中央が本発明の操作ボタンの例を示しており、さらに右側に対応したゲーム画面を示している。

【0049】本発明の操作ボタンは、奥側（図中上側）にスタート操作ボタン60、手前側（図中下側）左右に機能操作ボタン62，64を隣接配置しており、各スタート操作ボタン60、機能操作ボタン62，64のキートップ60a、62a，64a上面外縁には操作指66の挿入部分を残して単独操作用の凸部66，68，70が形成されている。同様に、独立型の操作ボタンにおいても、奥側にスタート操作ボタン72、手前側左右に機能操作ボタン74，76を所定の間隔を開けて配置している。

【0050】そして、例えば、スタート操作ボタン60，72ゲームのスタートあるいはポーズ機能をもたせ、機能操作ボタン62，74には対空ミサイル発射機能をもたせ、さらに機能操作ボタン64，76には対地ミサイル発射機能をもたせるようにしている。

【0051】この状態で、まずゲーム開始時には、図中（イ）に示すように、スタート操作ボタン60の凸部66を押下すると、ゲームがスタートし、ゲーム画面中央下側位置に自機80が表れ、かつバックの画像82が流れる。この場合、凸部66は、キートップ60aの上面より突出しているため、独立型のスタート操作ボタン72の操作と略同様の操作条件がえられる。

【0052】次に、バックの画像が流れている状態で、画面中にUFOや戦闘機等の敵84が出現したら、図中（ロ）で示すように、機能操作ボタン62の凸部68を押下して敵に対し対空ミサイル攻撃を行なう。この場合も、凸部68がキートップ62aの上面より突出しているため、独立型の機能操作ボタン74の操作と略同様の操作条件がえられる。

【0053】次いで、地上に基地86を発見したら、図中（ハ）で示すように、機能操作ボタン64の凸部70を押下して基地に対し対地ミサイルを発射して攻撃を行なう。この場合も、凸部70がキートップ64aの上面より突出しているため、独立型の機能操作ボタン76の操作と略同様の操作条件がえられる。

【0054】さらに、基地攻撃中にまたUFOや戦闘機等の敵84が接近してきた場合には、図中（ニ）で示すように、機能操作ボタン62，64を操作指一本で、同時に押下することにより、対地及び対空ミサイルを同時に発射して、対地、対空攻撃を同時に行なう。この場合、独立型の機能操作ボタン74，76は、間隔が離れているので、操作指一本での操作は困難であるのに対し、機能操作ボタン62，64は隣接しているので、両者に跨がった押圧操作が容易に行なえるものである。

【0055】そしてさらに、図示せぬが、スタート操作ボタン60及び両機能操作ボタン62，64の3つ同時操作で自機80にバリアを張ったり、あるいはスタート操作ボタン60及び機能操作ボタン62の2つ同時操作で単発のレーザー弾を発射させたり、さらにはスタート操作ボタン60及び機能操作ボタン64の2つ同時操作でナパーム弾を発射させたりすることが可能で、単独操作の場合に比し、同じ回線で信号数を増加させることが可能となる。

【0056】本発明は、前記各実施例に限定されるものではなく、本発明の要旨の範囲内において種々の変形実施が可能である。

【0057】例えば、前記各実施例においては、3個又は4個のキートップの集合の例を示したが、この例に限らず、5個以上のキートップの集合とすることも可能である。

【0058】また、集合状態における形状も、前述の円形又は楕円形に限らず、種々の形状を採用することが可能である。

【0059】

【発明の効果】請求項1によれば、少なくとも3種類のスイッチ操作用のキートップを集合状態で所定形状をなす分割形状に形成して隣接配置することにより、各キートップの単独操作は勿論のこと、2種類あるいは3種類以上のキートップを一本の指で同時に混合して組合せ操作することが容易になしうる。

【0060】また、キートップが散在している場合に比し、一度キー操作の動作をした後、操作指をニュートラル位置に戻すことが簡単に行なえ、しかもキートップが隣接しているので、操作指の腹の部分がキートップの角部に当ることが少なく、長時間の操作をする場合でも操作指が痛くなるような状態を避けることができる。

【0061】さらに、操作ボタンを集中配置しているので、スイッチ機構も独立して配置した場合に比し簡略化でき、コストの削減が可能で、操作盤上のスペースも少なくて済み、意匠的にも良好となる。

【0062】請求項2によれば、各キートップの操作盤カバーの内外に位置する隣接キートップとの接触面をキーストロークよりも長く形成することにより、各キートップが隣接して接触する状態であっても、キートップ同士が外れることなく確実な動作が期待できる。

【0063】請求項3によれば、各キートップの隣接キートップとの接触縁を除く上面外縁部に、操作盤カバーの取付孔との引掛かり防止用の曲面部を形成することにより、各キートップのスムーズな動作を期待することができる。

【0064】請求項4によれば、各キートップの上面外縁部に、各キートップを同時に操作する指挿入部分を残し、各キートップを単独操作するための凸部を形成することにより、各キートップの複合組合せ操作は勿論のこと、単独操作も誤操作することなく確実に操作することが可能となる。

【0065】請求項5によれば、ダミー用のキートップをニュートラルキーとして使用することにより、より一層誤操作を防止することが可能となり、しかもダミー用のキートップを指休めとして使用することにより、操作指の疲れを少なくでき、長時間のゲーム操作にも耐え得るものとすることができる。

【図面の簡単な説明】

【図1】本発明の一実施例に係る操作ボタンを備えるゲーム装置の操作盤を示す平面図である。

【図2】図1のII－II線に沿う断面図である。

【図3】本実施例のキートップと圧電スイッチとの関係を示す平面図である。

【図4】本発明の他の実施例を示す断面図である。

【図5】本発明の更に他の実施例を示すもので、同図（a）はその平面図、同図（b）は同図（a）のb－b線に沿う断面図である。

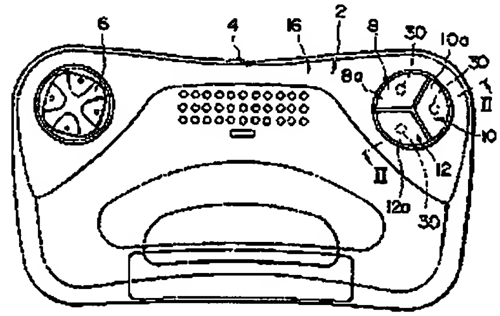
【図6】本発明の更に他の実施例を示す平面図である。＊

＊【図7】従来の操作ボタンとの関係において、本発明の操作ボタンの操作状態の一例を示す説明図である。

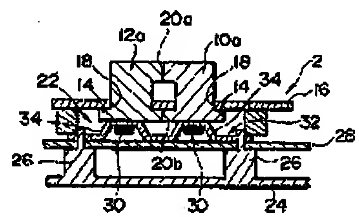
【符号の説明】

2　操作盤
8　スタートボタン
10，12　機能操作ボタン
8a，10a，12a　キートップ
16　上部ハウジング
20a、20b　接触面
30　圧電スイッチ
36　曲面部
38，40、42　キートップ
44　操作指の挿入部分
46，48、50　凸部
52，54、56、58　キートップ
L1　接触面の長さ
L2　キーストローク

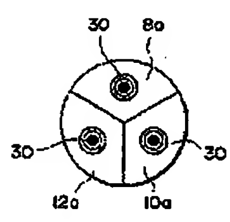
【図1】



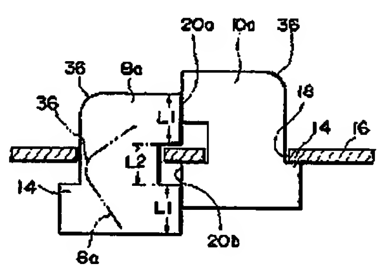
【図2】



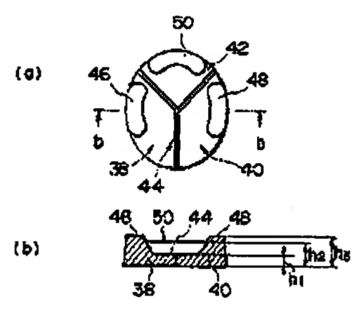
【図3】



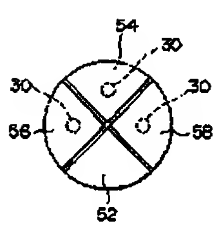
【図4】



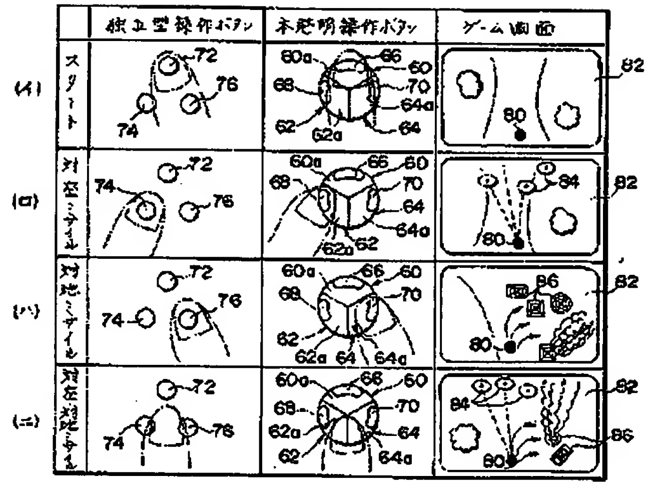
【図5】



【図6】



【図7】


従来型操作ボタン
本発明操作ボタン
ゲーム画面
(イ)
スタート
(ロ)
対空ミサイル
(ハ)
対地ミサイル
(ニ)
72
74
76
60
60a
62
62a
64
64a
66
68
70
80
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84
86

DOCUMENT 1/1
DOCUMENT NUMBER
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DETAIL JAPANESE

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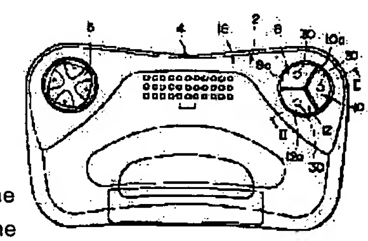
(71)Applicant : NAMCO LTD
(72)Inventor : SAKURAI SEIICHI
SAITO KUNIO

(54) OPERATION BUTTON OF GAME DEVICE

(57)Abstract:
PURPOSE: To provide an operation button of a game device by which mixing and combining operation of plural operation buttons is facilitated an occupied space on an operation board is reduced to provide good appearance in view of design and reduction of cost is made possible.
CONSTITUTION: Key tops 8a, 10a, 12a for operating at least three kinds of piezoelectric switches 30 of a game device are collected in one portion of an operation board 2, and the key tops 8a, 10a, 12a are formed in split-form to make a circle in the collecting state and disposed adjacent to one another. Thus, the mixing and combining operation of the two or three kinds of key tops as well as the individual operation for the respective key tops 8a, 10a, 12a can be carried out.



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[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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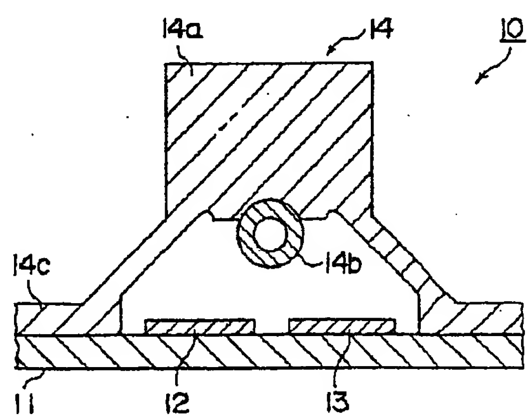
(54)【考案の名称】　感圧装置

(57)【要約】
【目的】本考案は、簡単な構成により、高い耐久性を有すると共に、操作性の良い抵抗変化が得られるようにした、感圧装置を提供することを目的とする。
【構成】基板11上にて互いに所定の間隔をもって対向するように形成された二つの固定接点部12，13と、該基板の上方にて上下動可能に支持された可動接点部14bとを含んでおり、該可動接点部が、導電物質を混入した弾性ゴムから成形され、且つその固定接点部に接触する部分が、下方に向かって凸状に形成されているように、感圧装置10を構成する。



【考案の詳細な説明】

【0001】

【産業上の利用分野】

本考案は、感圧装置に関し、特に応力に対して、電気抵抗が変化する感圧可変抵抗器に関するものである。

【0002】

【従来の技術】

従来、抵抗体と摺動接点とにより構成された可変抵抗器が、回路電圧の調整等のために使用されている。また、応力に対して電気抵抗が変化する半導体感圧素子の特性を利用したストレーンゲージ等のセンサが広く知られている。

【0003】

ところで、例えばコンピュータのカーソル移動やスクロールキー，自動車のパワーウィンドウスイッチ等は、単にオンとオフを切換えるスイッチであるが、これらのキーまたはスイッチに対して、操作者の意志に応じてアナログ的に操作量を調整することができる機能を付加すれば、所謂マンマシンインターフェースとしての性能向上が期待できる。

【0004】

このようなアナログ的操作を実現するためには、ハードウェア，ソフトウェアを変更する必要があると共に、キー，スイッチとしても、電気量調整手段としての可変抵抗器を備えたものを使用する必要があることは、明らかである。

【0005】

【考案が解決しようとする課題】

しかしながら、このようなキー，スイッチとして、従来の可変抵抗器を応用することは、体積，重量，耐久性やコスト等の多くの点から、問題がある。例えば、従来の機械式の可変抵抗器をキーボードのキーに用いることは、スペース的にも、また耐久性や操作性の点からも、問題が生ずることになる。

【0006】

本考案は、以上の点に鑑み、簡単な構成により、高い耐久性を有すると共に、操作性の良い抵抗変化が得られるようにした、感圧装置を提供することを目的と

している。

【0007】

【課題を解決するための手段】

上記目的は、基板上にて互いに所定の間隔をもって対向するように形成された二つの固定接点部と、該基板の上方にて上下動可能に支持された可動接点部とを含んでおり、該可動接点部が、導電物質を混入した弾性ゴムから成形され、且つその固定接点部に接触する部分が、下方に向かって凸状に形成されていることを特徴とする、感圧装置により、達成される。

【0008】

【作用】

上記構成によれば、可動接点部を上方から押圧したとき、該可動接点部が、下方に移動することにより、基板上の二つの固定接点部に対してブリッジ状に接触することになると共に、該可動接点部の下方の固定接点部に接触する部分が、下方に向かって凸状に形成されていることから、可動接点部の押圧力が大きいほど、該可動接点部は、押し潰されるように扁平形状に変形することになり、該固定接点部に対する接触面積が大きくなる。

【0009】

従って、可動接点部の押圧力が大きくなるに従って、該可動接点部の固定接点部に対する接触面積が徐々に大きくなることにより、上記二つの固定接点部の間の電気抵抗値は、徐々に減少することになり、押圧力に応じた電気抵抗値の変化が得られることになる。

【0010】

ここで、上記構成においては、可動接点部及び固定接点部のみにより、感圧装置が構成され得るので、構成が簡単で、且つ低コストで製造され得ると共に、断線等の故障発生が殆どなく、耐久性に優れており、また小型に構成され得ることから、キーボードのキー等に容易に組み込まれ得ることとなり、応用範囲が非常に広く拡大され得ることになる。

【0011】

【実施例】

以下、図面に示した実施例に基づいて、本考案を詳細に説明する。
図１は、本考案による感圧装置の一実施例を示している。

【００１２】

図１において、感圧装置１０は、基板１１上にて互いに所定の間隔をもって対向するように、導電パターン等により形成された二つの固定接点部１２，１３と、該基板１１の上方に配設された所謂ラバーキートップ１４とから構成されている。

【００１３】

該ラバーキートップ１４は、その本体１４ａの下端に取り付けられた可動接点部１４ｂと、該本体１４ａを上下動可能に支持すると共に、基板１１の表面に取り付けられる脚部１４ｃとから構成されており、カーボンブラックやグラファイト等の炭素粉末の混入したシリコンゴム等の弾性ゴム材料から、一体形成されている。

【００１４】

ここで、該ラバーキートップ１４の可動接点部１４ｂは、図示の場合、中空円筒状に形成されており、その下端が、下方に向かって凸状の形状を有している。

【００１５】

本考案による感圧装置１０は、以上のように構成されており、ラバーキートップ１４を上方から押圧すると、この押圧力に基づいて、該ラバーキートップ１４が下方に移動せしめられる。

【００１６】

そして、図２に示すように、該ラバーキートップ１４の可動接点部１４ｂの下端が、基板１１上の二つの固定接点部１２，１３に接触したとき、該固定接点部１２，１３が、該可動接点部１４ｂを介して、互いに電気的に接続され得ることになる。このとき、押圧力をＦａとして、該可動接点部１４ｂの固定接点部１２，１３に対する接触面積が小さいことから、該固定接点部１２，１３の間の電気抵抗値Ｒは、最大値をとる。

【００１７】

この状態から、該ラバーキートップ１４をさらに下方に押圧して、押圧力をＦ

ｂとすると、図３に示すように、該ラバーキートップ１４の可動接点部１４ｂが、弾性変形して、扁平形状に押し潰されることになる。これによって、該可動接点部１４ｂの固定接点部１２，１３に対する接触面積が大きくなり、従って、該固定接点部１２，１３の間の電気抵抗値Ｒは、小さくなる。

【００１８】

このようにして、該ラバーキートップ１４の押圧力Ｆに基づいて、該固定接点部１２，１３の間の電気抵抗値Ｒは、図４のグラフに示すように、比較的大きく変化することになる。

【００１９】

図５は、図１の実施例における可動接点部１４ｂの変形例を示している。即ち、図４において、可動接点部２０は、その断面形状にて、上端２０ａが平坦に形成され、且つ下端２０ｂが下方に向かって凸状になるように、中空状に形成されている。

【００２０】

このように構成された可動接点部２０の場合にも、前記中空円筒状の可動接点部１４ｂの場合と同様に、押圧力に対応して、該可動接点部２０が扁平形状に押し潰されることになり、固定接点部１２，１３に対する接触面積が、大きくなる。従って、押圧力に比例して、電気抵抗値が小さく変化することになる。

【００２１】

尚、可動接点部の形状は、上述した可動接点部１４ｂ、２０の形状に限らず、押圧力Ｆに応じて、固定接点部１２，１３に対する接触面積が大きくなるような、少なくとも下方に向かって凸状の形状であればよい。

【００２２】

【考案の効果】

以上述べたように、本考案によれば、簡単な構成により、高い耐久性を有すると共に、操作性の良い抵抗変化が得られるようにした、極めて優れた感圧装置が提供され得ることになる。

JAPANESE LAID-OPEN UTILITY
MODEL APPLICATION

H6-56740 (1994)

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(12) Published Laid-Open Utility Model (U)		(43) Publication Date	August 5, 1994	
(51) Int. Cl.^{5}	Identification Code	In-House Reference Number	FI	Place of Technical Desigation
G 01 L 1/18				

No examination request   Number of claims 1 FD (totally 2 pages)

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(22) Date of Filing	January 14, 1993 (Heisei 5)

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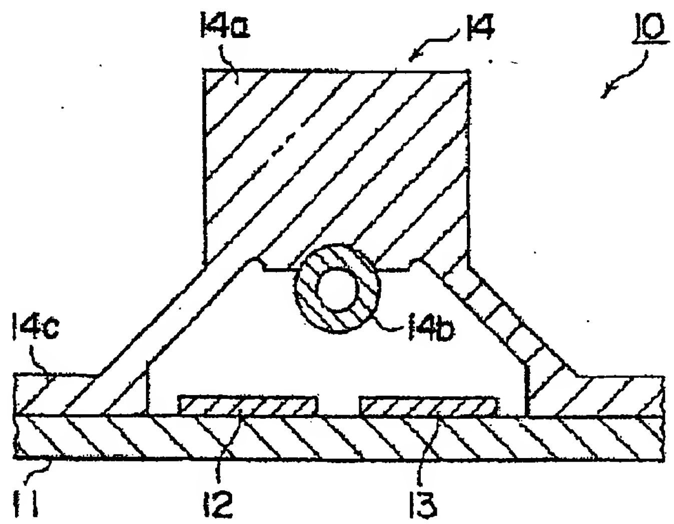
(54) **[Title of the Invention]** Pressure Sensitive Device

(57) **[Abstract]**

[Purpose] The purpose of the present invention is to provide a pressure sensitive device having high durability and which provides resistance change with good operability.

[Structure] A pressure sensitive device **10** which includes two fixed contacts **12** and **13** formed opposite each other at prescribed spacing on a board **11** and a movable contact **14b** supported above the board **11** in a vertically movable way and is so structured that the movable contact is formed of an elastic rubber mixed with a conductive substance and a part in contact with the fixed contacts is formed convexly downward.



[Claims]

[Claim 1] A pressure sensitive device which includes two fixed contacts formed so as to oppose each other at prescribed spacing on a board and a movable contact supported above the board

NAA00002555

in a vertically movable way and is characterized by the fact that the movable contact is formed of an elastic rubber mixed with a conductive substance and the part in contact with the fixed contacts is formed convexly downward.

[Brief description of the drawings]

[Fig. 1] Schematic sectional view showing an example of a pressure sensitive device based on the present invention.

[Fig. 2] Partial sectional view showing a state in which a rubber key top of the pressure sensitive device of Fig. 1 is pushed by a pushing force Fa.

[Fig. 3] Partial sectional view showing a state in which a rubber key top of the pressure sensitive device of Fig. 1 is pushed by a larger pushing force Fb.

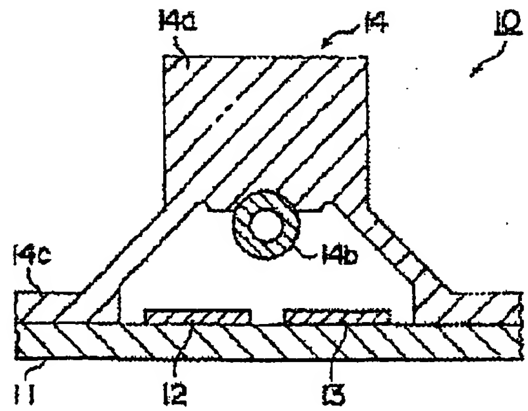
[Fig. 4] Graph showing the relationship between the pushing force F and the electric resistance value R between fixed contacts in the pressure sensitive device of Fig. 1.

[Fig. 5] Partial oblique view showing a modification example of a movable contact in the pressure sensitive device of Fig. 1.

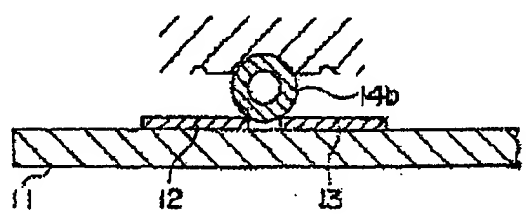
[Description of the symbols]

10	pressure sensitive device
11	board
12, 13	fixed contacts
14	rubber key top
14a	main body
14b, 20	movable contacts
14c	foot

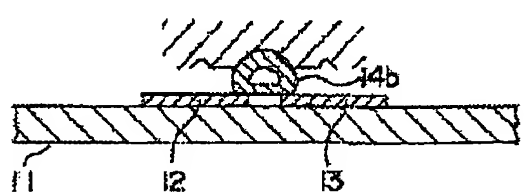
[Fig. 1]



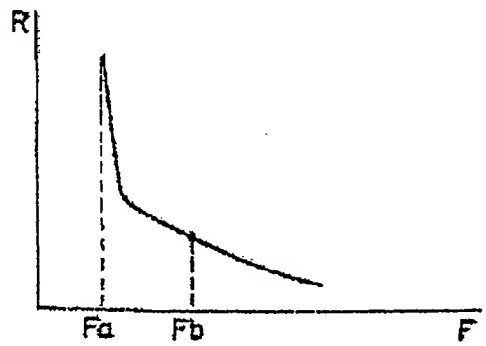
[Fig. 2]



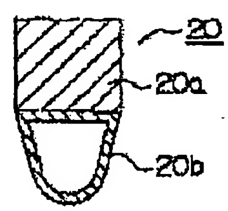
[Fig. 3]



[Fig. 4]



[Fig. 5]



[Detailed Description of the Invention]

[0001]

[Field of Industrial Application]

The present invention relates to a pressure sensitive device, and particularly to a pressure sensitive device in which the electric resistance changes relative to stress.

[0002]

[Prior art]

Variable resistors constructed by a resistor and a slide contact have been used heretofore to regulate circuit voltage. Sensors using the characteristics of a semiconductor pressure sensitive device in which the electric resistance changes relative to stress, such as a torque gauge, etc. have been widely known.

[0003]

For example, the cursor movement keys and scroll keys of a computer, power window switches of an automobile, etc. are switches for simply switching ON and OFF. However, if a function capable of analogically adjusting the control input in accordance with the will of an operator is added, performance improvement as a so-called man-machine interface may be anticipated for these keys or switches.

[0004]

To realize such analog operation, it is evident that software and hardware must be changed and keys, switches provided with a variable resistor as a regulating means of electric quantity must be employed.

[0005]

[Problem overcome by the invention]

However, for such keys and switches, the application of conventional variable resistors has several problems from the standpoint of volume, weight, durability and cost, etc. For example, the use of a conventional mechanical variable resistor in the keys of a keyboard also causes problems from the standpoint of space, durability and operability.

[0006]

In view of the above, the purpose of the present invention is to provide a pressure sensitive device that has a high durability and provides resistance change with good operability by a simple structure.

[0007]

[Problem resolution means]

The above purpose is achieved by a pressure sensitive device which includes two fixed contacts formed so as to oppose each other at prescribed spacing on a board and a movable contact supported above the board in a vertically movable way and is characterized by the fact that the movable contact is formed of an elastic rubber mixed with a conductive substance, and the part in contact with the fixed contacts is formed convexly downward.

[0008]

According to the above structure, when the movable contact is pushed from the above, the movable contact comes into contact with the two fixed contacts on the board like a bridge by moving downward, the part in contact with the fixed contacts below the movable contact being formed convexly downward, therefore the greater the pushing force of the movable contact, the more the movable contact deforms in a flattened collapsed-like shape and the more the contact area with the fixed contacts will become.

[0009]

Accordingly, the electric resistance value between the two fixed contacts is slowly reduced and change of the electric resistance value corresponding to the pushing force is obtained by slowly increasing the contact area of the movable contact with the fixed contacts.

[0010]

The pressure sensitive device has a simple structure and can be manufactured at low cost because it can be structured by only the movable contact and the fixed contacts in the above structure, and the pressure sensitive device can be easily incorporated into the keys of a key-board because it has excellent durability and can be structured in a small size, widely expanding its range of application.

[0011]

[Example]

The present invention is described in detail hereafter, based on the example shown in the drawings.

Fig. 1 shows an example of a pressure sensitive device based on the present invention.

[0012]

In Fig. 1, a pressure sensitive device **10** is structured from two fixed contacts **12** and **13** formed according to a conductive pattern so as to oppose each other at prescribed spacing with a so-called rubber key top **14** arranged above the board **11**.

[0013]

The rubber key top **14** is constructed from a movable contact **14b** mounted to the lower end of the main body **14a** and a foot **14c** vertically and movably supporting the main body **14a** and mounted to the surface of board **11**, being integrally formed of an elastic rubber material, such as a silicone rubber mixed with a carbon powder like carbon black or graphite, etc.

[0014]

As an illustration, the movable contact **14b** of the rubber key top **14** is formed in the shape of a hollow cylinder, and its lower end is shaped convexly downward.

[0015]

The pressure sensitive device based on the present invention is structured as above, and if the rubber key top **14** is pushed from above, the rubber key top **14** can be moved down.

[0016]

As shown in Fig. 2, when the lower end of movable contact **14b** of the rubber key top **14** comes into contact with the two fixed contacts **12** and **13** on the board **11**, the fixed contacts **12** and **13** can be electrically connected to each other via the movable contact **14b**, at which time the electric resistance value R becomes the maximum value because the pushing force is Fa and the contact area of the movable contact **14b** with the fixed contacts **12** and **13** is small.

[0017]

If the rubber key top **14** is further pushed down from this state and the pushing force is Fb, as shown in Fig. 3, the movable contact **14b** of the rubber key top **14** is elastically deformed and

collapsed in a flattened shape, increasing the contact area of the movable contact **14b** with the fixed contacts **12** and **13**, reducing the electric resistance value R between the fixed contacts **12** and **13**.

[0018]

In this manner, as shown in a graph of Fig. 4, the electric resistance value R between the fixed contacts **12** and **13** changes considerably on the basis of the pushing force F of the rubber key top **14**.

[0019]

Fig. 5 shows a modification example of the movable contact **14b** in the example of Fig. 1. Namely, in Fig. 4, the movable contact **20** is formed in a hollow shape by its cross-section so that the upper end **20a** is formed flat and the lower end **20b** becomes convex downward.

[0020]

In the case of movable contact **20** thus constructed, as with the case of the hollow cylindrical contact **14b**, the movable contact **20** is collapsed in a flattened shape corresponding to the pushing force, increasing the contact area with the fixed contacts **12** and **13**. Accordingly, the electric resistance value changes little in proportion to the pushing force.

[0021]

The shape of above-mentioned movable contacts is not limited to the shape of **14b**, **20** and may be at least a downward convex shape so that the contact area with the fixed contacts **12** and **13** increases in accordance with the pushing force F.

[0022]

[Efficacy of the invention]

As described above, the present invention can provide an extremely excellent pressure sensitive device that has high durability and provides resistance change with good operability by means of a simple structure.

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25405, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Utility Model
JP H6-56740
"Pressure Sensitive Device"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

October 24, 2006

⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　平1－62627

⑤Int.Cl.⁴	識別記号	庁内整理番号	㊸公開　平成1年（1989）4月21日
H 01 H 13/52		F－8729－5G	
1/06		H－6969－5G	
			審査請求　有　（全　頁）

㊿考案の名称　可変抵抗型ラバースイッチ

㉑実　願　昭62－156738

㉒出　願　昭62（1987）10月15日

⑦考案者　浅野　靖文　東京都北区田端5丁目14番14号　富士ゴム株式会社テクニカルセンター内

⑪出願人　富士ゴム株式会社　東京都中央区日本橋本町4丁目8番16号

⑭代理人　弁理士　松田　省躬

[redacted]

明　細　書

1．考案の名称　可変抵抗型ラバースイッチ

2．実用新案登録請求の範囲

電極と接点部が相対向して配置されているスイッチにおいて、接点部が弾性の導電ゴムであって、電極と対向する表面が平坦となっていない可変抵抗型ラバースイッチ。

3．考案の詳細な説明

［産業上の利用分野］

本考案は、各種エレクトロニクス機器のスイッチに使用される接点部の改良に関するものである。

従来の弾性の導電ゴムを接点部に使用した電極と接点が相対向するように配置されたいわゆるラバースイッチは、ON－OFF型のスイッチである。

この従来のスイッチには、スイッチを押す力の大小に応じて、機器の動作の状態を変化させる機能は有していない。

［考案の構成］

そこで本考案は、接点の弾性導電ゴムの電極と

実開1-[illegible]

[redacted]

対向する表面を平担面とせず、例えば球状または円周状あるいは直径方向に溝を設けた表面とすることにより、スイッチを押す力に応じて、導電弾性体と電極との接触面積に変化を与え、これにより抵抗値の変化が得られるようにしたものである。

導電接点ゴムは、弾性体であるので押圧力が加わるとたわみ、導電接点ゴムと電極との接触面積が大となる。電極の抵抗は、導電接点ゴムとの接触面積に反比例するから、圧力が加わるに従い抵抗値が下がる。

実施例1

次に第1(1)図に示す実施例に従って説明する。

絶縁性の弾性ゴムからなる中空の円錐形状のバネ1の内面天井部に導電性の導電弾性体から成る導電接点ゴム2が同時成型あるいは接着等により形成されている。この導電接点ゴム2は半球状に凸となった形状としてある。3はプリント基板である。

第1(2)図は、少し押圧した状態を示し、第1(3)図は、完全に押圧した状態を示す。

[redacted]

そして第２図は、第１図の導電接点ゴム２の位置に対応した電極４との接触面積の変化を示しており、それぞれ押圧力に応じて導電接点ゴムがたわみ、接触面積が変化する。

第1(1)図の押圧してない状態が、第2(1)図に示され、第1(2)図の半分押圧した状態では、第2(2)図のように、わずかの面積のみしか導電接点ゴム２と電極４とが接触しておらず、第1(3)図の完全に押した状態では、第2(3)図に示すように大面積にわたり接触している。

<u>実施例２</u>

第３図には、第１図とは別の実施例を示す。

この実施例では、中空の円錐形状の絶縁ゴムのバネ５の内面天井に形成した導電接点ゴム６が、環状に凹凸が付けてある。そしてこのスイッチにおける押圧力に応じた導電接点ゴム６とプリント基板の電極７との接触面積の変化を第４図に示してあり、第4(1)図は押圧力してない状態であり、第4(2)図が半分押圧した状態であり、第4(3)図が完全に押圧した状態を示す。

[redacted]

［考案の効果］

このように構成することで、スイッチの押圧力に応じて導電接点ゴムがたわみ、電極との接触面積が変化し、抵抗値が変わることにより、単にスイッチングのＯＮ－ＯＦＦのみでなく機器の動作状態を変化させる機能をもたせることが可能となる。

第５図には、従来のスイッチと本考案のスイッチとの押圧力と抵抗値との関係の違いをグラフに示してある。

４．図面の簡単な説明

第１図は、スイッチの押圧力に応じた変化状態を示す構造概略図。

第２図は、スイッチの押圧力に応じた導電接点ゴムと電極との接触面積の変化状態を示す図。

第３図は、別の実施例を示すスイッチの構造概略図。

第４図は、第３図のスイッチにおける押圧力に応じた導電ゴムと電極との接触面積の変化状態を示す図。

[redacted] [redacted]

第5図は、押圧力と抵抗値の関係を示す図。

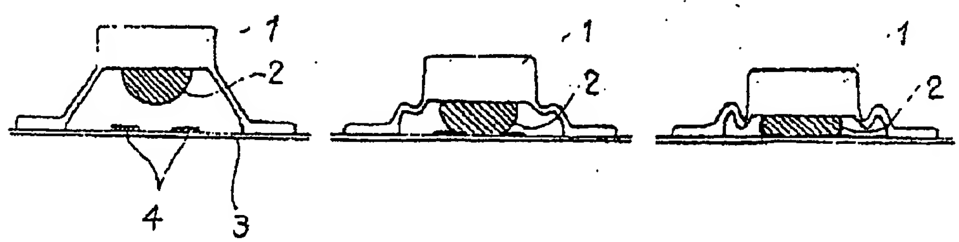
1・・・・バネ　　2・・・・導電接点ゴム
3・・・・プリント基板　　4・・・・電極
5・・・・バネ　　6・・・・導電接点ゴム

実用新案登録出願人　　富士ゴム株式会社
代理人　弁理士　　松 田 省 躬

[redacted]

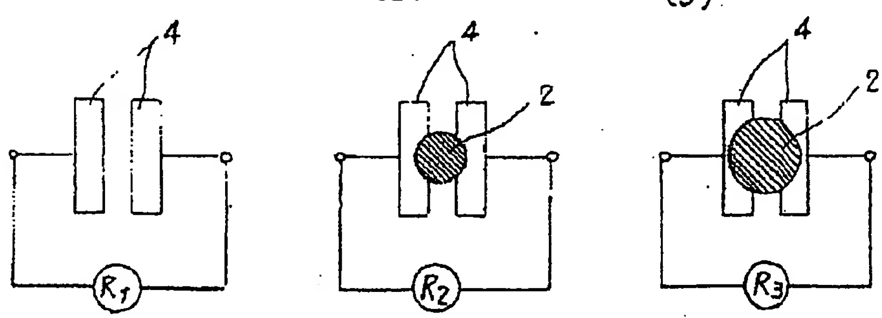
第1図

(1) (2) (3)

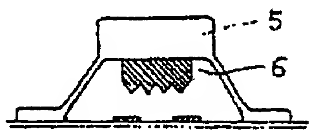


第2図

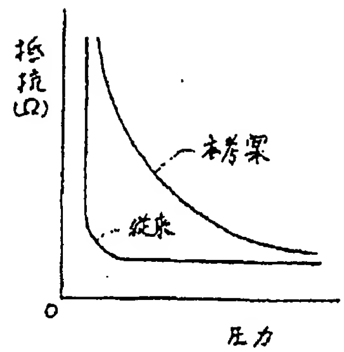
(1) (2) (3)



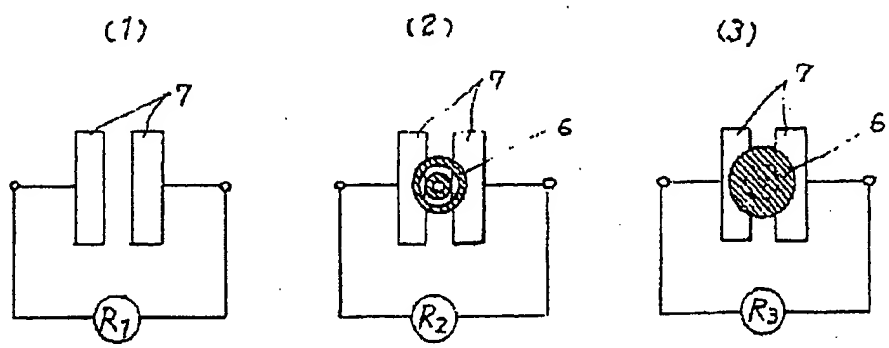
第3図



第5図



第4図



実開 1- 62627

Laid Open Utility Model HEI1-62627

(19) Japan Patent Office (JP)

(11) Publ. of Utility Model Application

(12) Publication of Laid Open Utility Model (U)

H1-62627

(51) Int. Cl[3]	Class/ No.	Int. Control No.	(43) Publ. Date: 04/21/1989
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1/06		H-6969-5G	

Examination Request Yes
Certification Request: Yes
(Altogether 3 pages)

(54) Title of the Invention: Variable Resistance Rubber Switch
(21) Patent Application No.: Sho 62-156738
(22) Date Filed: October 15, 1987
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Fuji Rubber Co.; Ltd.Technical Center

(71) Applicant: Fuji Rubber Co.; Ltd.
Tokyo-to, Chuo-ku, Nihonbashi, Honcho 4 Chome 8 Ban 16 Go

(74) Agent Attorney: Matsuda, S.

Specification

1. Title of the invention: Variable Resistance rubber switch

2. Scope Of Utility Model Registered Claims

A variable resistance rubber switch, wherein, in a switch in which the electrode and contact are arranged so as to relatively face one another, the contact is formed of elastic electro-conductive rubber, and the surface facing the electrode is not flat.

3. Detailed Explanation of the Invention

Industrial applications

The present invention relates to an improvement in the contact used in switches for each type of electronic component.

A so-called rubber switch arranged so that the electrode and contact in which conventional electro-conductive rubber is used are arranged so as to face another, is an ON-OFF switch.

In a conventional switch, there is no function for changing the state of the operation of a device corresponding to the size of the pressure force on the switch.

Structure of the invention

Therefore, with present invention, the surface facing the contact elastic electro-conductive rubber electrode is not a flat surface, and, for example, by providing a spherical or circumferential shape, or a groove across the diameter, the contact surface area between the electro-conductive elastic body and the electrode is changed corresponding to the pressure force of the switch, thereby changing the resistance value.

Since the electro-conductive contact rubber is elastic, it bends with the application of pressure, increasing the contact area between the electro-conductive contact and the electrode. Since the electrode resistance is inversely proportional to the contact area with the electro-conductive contact, there is a reduction in the resistance value with the application of pressure.

Embodiment 1

An explanation is provided next of the embodiment shown in Figure 1(1).

The electro-conductive contact rubber 2 formed from an electro-conductive elastic body on the inner surface ceiling of the centrally hollow conical spring 1 formed of insulating elastic rubber is formed with a hemispherical protrusion, which is either simultaneously formed or adhered with an adhesive. No. 3 represents a print board.

Figure 1(2) shows a slightly pressured state. Figure 1(3) shows a completely pressured state.

Also, Figure 2 shows changes in the contact surface area of the electrode 4 corresponding to the position of the electro-conductive contact rubber 2 of Figure 1, in which the contact area changes with bending of the electro-conductive contact rubber, corresponding to the pressure applied.

The state in Figure 1 (1) in which no pressure is applied is shown in Figure 2 (1), and in the state of half pressure shown in Figure 1 (2), as shown in Figure 2 (2), there is no more than a slight area in which contact occurs between the electro-conductive point rubber 2 and the electrode 4, and in the state of complete pressure shown in Figure 1 (3), contact is made across a great area such as is shown in Figure 2 (3).

Embodiment 2

Figure 3 shows another embodiment of Figure 1.

In this embodiment, electro-conductive contact rubber 6 formed on the inner surface ceiling of the spring 5 of the centrally hollow conical insulating rubber with annular unevenness. Also, changes in the contact area between the electrode 7 of the print substrate and the electro-conductive contact rubber 6 corresponding to the pressure force in the switch are shown in Figure 4. Figure 4 (2) shows a half pressure application, and Figure 4 (3) shows the application of complete pressure.

Efficacy of the invention

With such a structure, the electro-conductive contact rubber bends corresponding to the pressure force of the switch, and the contact surface area with the electrode changes. Through changes in the resistance value, not only is there simple ON-OFF switching, but a function is also possible which changes the operational state of a device.

Figure 5 is a graph which shows the difference in the relationship between the pressure force and the resistance value of a conventional switch and the switch of the present invention.

4. Brief explanation of drawings

Figure 1 is a construction summary diagram showing the state of change corresponding to the pressure force of the switch.

Figure 2 is a diagram which shows the state of change of the contact area between the electrode and the electro-conductive contact corresponding to the pressure force of the switch.

Figure 3 is a construction abbreviated drawing of a switch which shows a separate embodiment.

Figure 4 is a diagram which shows the state of change between the contact area between the electro-conductive rubber and an electrode, corresponding to the pressure force of the switch shown in Figure 3.

Figure 5 is a diagram showing the relationship between pressure force and resistance value.

1: spring
2: electro-conductive contact rubber
3: print board
4: electrode
5: spring
6: electro-conductive contact rubber

Applicant; Utility Model Registration: Fuji Rubber Co., Ltd.
Agent Attorney: Matsuda, S.

FIGURE 1

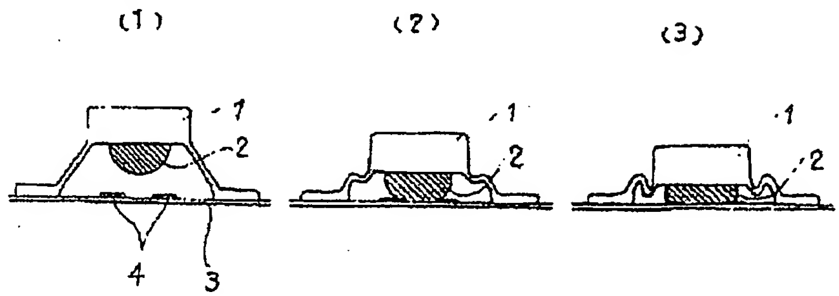


FIGURE 2

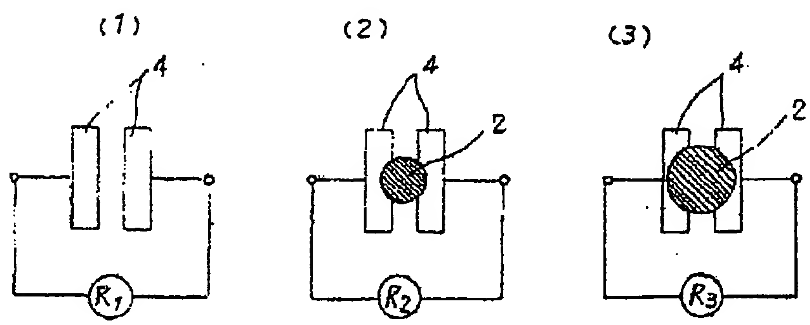


FIGURE 3

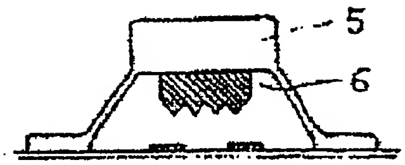


FIGURE 4

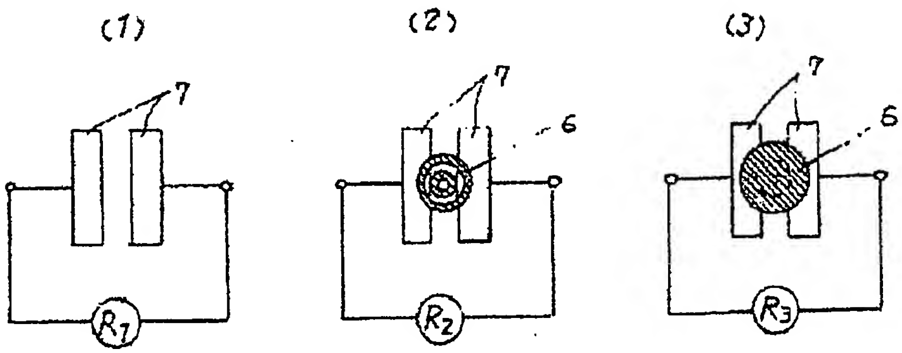
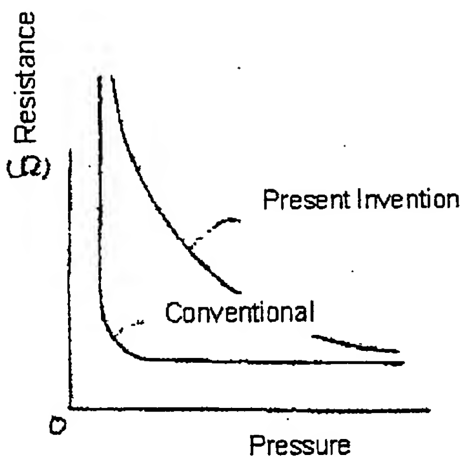


FIGURE 5



CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25405, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

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Laid Open Patent Publication
JP H1-62627
"Variable Resistance Rubber Switch"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

October 24, 2006

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特開平5－190051

(43)公開日　平成5年(1993)7月30日

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H01C 10/10	A			
H01H 13/52	F	4235－5G		

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(21)出願番号　特願平4－3464

(22)出願日　平成4年(1992)1月13日

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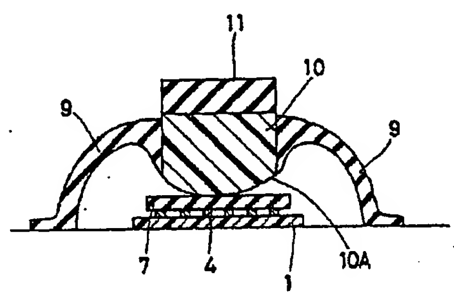
(74)代理人　弁理士　志賀　富士弥　（外3名）

(54)【発明の名称】　感圧スイッチ

(57)【要約】

【目的】　耐久性を高め、安定した抵抗値を得られる。

【構成】　基板1の電極4上に載置された板状の感圧導電ゴム7と、この感圧導電ゴム7を押圧する球面状の押圧部10Aを備えた押圧子10とを有する。



1----基板
4----電極
7----感圧導電ゴム(導電ゴム)
10----押圧子
10A----押圧部

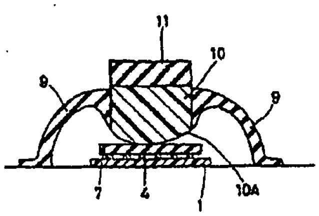
NAA00003208

【特許請求の範囲】
【請求項1】　基板等の電極上に載置された板状の導電ゴムと、この導電ゴムを押圧する球面状の押圧部を備えた押圧子とを有することを特徴とする感圧スイッチ。
【発明の詳細な説明】
【0001】
【産業上の利用分野】この発明は、感圧スイッチに関するものである。
【0002】
【従来の技術】スイッチの中には、例えば、図5に示すものが知られている。
【0003】これは、第1の基板1に第2の基板2をスペーサ3を介して片持ち状に支持し、第1の基板1上に電極4間を抵抗体5で連結する一方、第2の基板2の先端に導電性ゴムから成る断面三角形状の接点6を取り付けたものである（特開平2－275603号公報）。
【0004】このスイッチにおいては、第2の基板2の先端側に力Fが作用すると、第2の基板2が撓み、接点6が抵抗体5上でつぶれを生ずる。力Fが大きくなると接点6のつぶれ量が大きくなるため抵抗体5との接触面積が増え、したがって、抵抗体5の実質的長さが小さくなり、抵抗値が下がるのである。
【0005】
【発明が解決しようとする課題】しかしながら上記従来の感圧スイッチにおいては、接点6の先端が断面三角状に形成されていたため経時的使用によってこの接点6がへたりを生じたり変形するという問題がある。
【0006】これに対して、図4に示すように平板状の導電ゴム7を基板1の電極4上に載置し、これを上方から押圧子8で加圧する構造のものが案出されているが、押圧子8の加圧面が平面状であったため、除圧の際の加圧面の離れ方に偏りがでてしまう等の理由により抵抗値が不安定になってしまう。
【0007】そこで、この発明は耐久性があり、安定した抵抗値を得ることができる感圧スイッチを提供するものである。
【0008】
【課題を解決するための手段】基板等の電極上に載置された板状の導電ゴムと、この導電ゴムを押圧する球面状の押圧部を備えた押圧子とを有する。
【0009】
【作用】押圧子の押圧部を球面状に形成して加圧応力を集中させると共に押圧子周辺への応力逃げを防止し、安定した抵抗値変化を得る。
【0010】
【実施例】以下、この発明の一実施例を図面と共に説明する。
【0011】図1に示すように、基板1の電極4上には、板状の導電ゴムとしての感圧導電ゴム7が載置されている。
【0012】感圧導電ゴム7はシリコンゴムを100重量部、FETカーボン50重量部に加硫剤を2重量部添加して形成された厚さ1mm程度の板状部材であって、加圧されると内部のカーボンの密度が高まると共に電極4と確実に接触するため、抵抗値が小さくなるものである。
【0013】そして、この感圧導電ゴム7にゴム製のスプリング9によって姿勢復帰可能に支持された樹脂製の押圧子10が対向配置されている。
【0014】押圧子10には、感圧導電ゴム7を押圧する押圧部10Aが設けられ、この押圧部10Aは球面状に形成されている。
【0015】尚、押圧子10の上部にはゴム製のキートップ11が取り付けられている。
【0016】上記実施例構造によれば、キートップ11を押圧すると、スプリング9に抗して押圧子10が下がり、感圧導電ゴム7が押圧子10の押圧部10Aによって加圧される。
【0017】これによって、感圧導電ゴム7の内部のカーボンの分布密度が高まると共に電極4に確実に接触するため、この荷重が大きい程抵抗値が小さくなる。
【0018】ここで、感圧導電ゴム10は平板状に形成してあるため、へたりや変形が少なく、耐久性が著しく向上する。また、押圧子10の押圧部10Aが球面状に形成されているため、加圧応力を集中させることができると共に押圧子10周辺への応力逃げが防止され安定した押圧力に対する抵抗値変化が得られる。
【0019】次に、図2に実験結果を示す。
【0020】図3に示すように押圧子10の押圧部10Aが球面である場合と、図4に示すように押圧子8の押圧部8Aが平坦円である場合について、抵抗値（Ω）と荷重（g）との関係を調べてみると、加圧、除圧のヒステリシスが小さく特性が安定しているのは押圧部10Aが球面の方であることが明らかになった。尚、使用されたサンプルは球面の押圧部10Aのもの3種（半径R＝2．5、5、10）と平坦円の押圧部8Aのもの（直径φ＝5、10）の2種であった。また使用された基板1の電極4は、導体幅0．3mm、ピッチ0．6mmのものである。
【0021】この実験からも、押圧部が球面の押圧部の方が安定した特性が得られることがわかる。
【0022】
【発明の効果】以上説明してきたようにこの発明によれば、板状の導電ゴムを用いているため、耐久性が高くなる。また押圧子の押圧部が球面状に形成されているため、除圧、加圧の際に加圧応力を集中させることができると共に押圧子周辺への応力逃げが防止され安定した抵抗値変化を得ることができる。
【図面の簡単な説明】
【図1】この発明の一実施例の断面図。

【図２】同グラフ図。
【図３】テストピースの断面図。
【図４】従来技術に対応するテストピースの断面図。
【図５】従来技術の断面図。

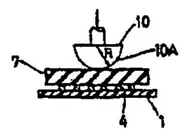
【符号の説明】
１…基板、４…電極、７…感圧導電ゴム（導電ゴム）、
１０…押圧子、１０Ａ…押圧部。

【図１】

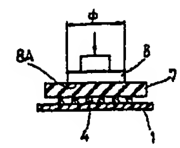


1……基板
4……電極
7……感圧導電ゴム(導電ゴム)
10……押圧子
10A…押圧部

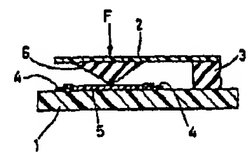
【図３】



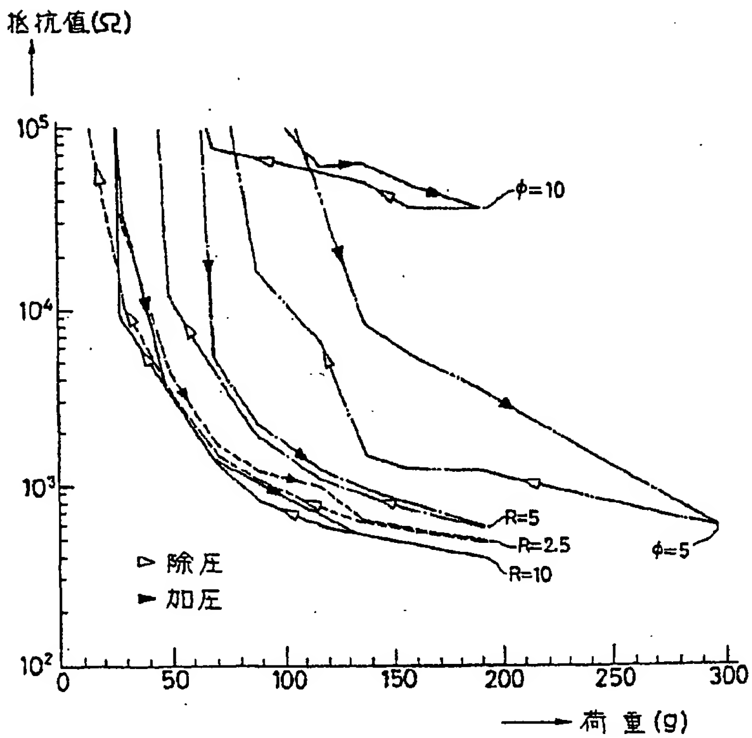
【図４】



【図５】



【図２】



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(54) [Title of the invention] Pressure-sensitive switch

(57) [Abstract]

[Objective]

To improve durability and yield stable resistance.

[Construction]

A plate of pressure-sensitive electro-conductive rubber 7 placed on electrodes 4 of a substrate 1 and a presser 10 having a spherical pressing part 10A for pressing the pressure-sensitive electro-conductive rubber 7 are provided.

[Claim]

[Claim 1]

A pressure-sensitive switch comprising a plate of electro-conductive rubber placed on the electrodes of a substrate and a presser having a spherical pressing part for pressing said electro-conductive rubber.

[Detailed explanation of the invention]
[0001]
[Scope of the invention]

The present invention relates to a pressure-sensitive switch.

[0002]

[Prior art technology]

A switch shown in Fig.5 is among known switches.

[0003]

Here, a first substrate 1 supports a second substrate 2 in a cantilever manner via a spacer 3. Electrodes 4 on the substrate 1 are connected by a resistor 5. An electro-conductive rubber contact 6 of a triangular cross-section is attached to the tip of the second substrate 2 (Japanese Laid-Open Patent Application No. H02-275603).
[0004] With this switch, when a force F is applied to the tip of the second substrate 2, the second substrate 2 is bent and the contact 6 collapses on the resistor 5. As the force F is increased, the contact 6 collapses more and makes contact with the resistor 5 in a larger area. Therefore, the substantial length of the resistor 5 is reduced, decreasing its resistance.

[0005]

[Problems overcome by the invention]

However, in the prior art pressure-sensitive switch described above, the contact 6 has a triangular cross-section at the tip, subjecting the contact 6 to fatigue or deformation after prolonged use.

[0006]

On the other hand, in another proposed structure, as shown in Fig.4, a plate of electro-conductive rubber 7 is placed on electrodes 4 of a substrate 1 and pressed from

above by a presser 8. Here, the presser 8 has a flat pressing surface, with the problem that the pressing surface may be released unevenly upon removal of the pressure, therefore providing unstable resistance.

[0007]

Hence, the present invention provides a pressure-sensitive switch having durability and yielding stable resistance.

[0008]

[Problem resolution means]

A plate of electro-conductive rubber 7 placed on electrodes 4 of a substrate 1 and a presser 10 having a spherical pressing part 10A for pressing the electro-conductive rubber 7 are provided.

[0009]

[Efficacy]

The presser has a spherical pressing surface so as to concentrate the applied pressure stress and to prevent the stress from escaping to around the presser, yielding stable changes in resistance.

[0010]

[Embodiment]

An embodiment of the present invention is described hereafter with reference to the drawings.

[0011]

As shown in Fig.1, a pressure-sensitive electro-conductive rubber 7 made of a plate of electro-conductive rubber is placed on electrodes 4 of a substrate 1.

[0012]

The pressure-sensitive electro-conductive rubber 7 is in the form of a plate made from 100 parts by weight of silicon rubber and 50 parts by weight of FET carbon with the addition of 2 parts by weight of a vulcanizing agent and having a thickness of approximately 1 mm. When pressured, the pressure-sensitive electro-conductive rubber 7 has increased internal carbon density and makes secure contact with the electrodes 4, exhibiting decreased resistance.

[0013]

Facing the pressure-sensitive electro-conductive rubber 7, a resin presser 10 is supported by a rubber spring 9 such that it is allowed to recover its posture.

[0014]

The presser 10 has a spherical pressing part 10A for pressing the pressure-sensitive electro-conductive rubber 7.

[0015]

Here, the presser 10 has a rubber key top 11 at the top.

[0016]

In the above embodiment, when the key top 11 is pressed, the presser 10 is lowered against the spring 9 and the pressure-sensitive electro-conductive rubber 7 is pressured by the pressing part 10A of the presser 10.

[0017]

Consequently, the pressure-sensitive electro-conductive rubber 7 has an increased internal carbon distribution density and makes secure contact with the electrodes 4, decreasing the resistance as the load is increased.

[0018]

The pressure-sensitive electro-conductive rubber 10 is in the form of a plate and, therefore, undergoes less fatigue, having significantly increased durability. The pressing part 10A of the presser 10 is spherical so as to concentrate the applied pressure stress and to prevent the stress from escaping around the presser 10, yielding stable changes in resistance for the applied pressure.

[0019]

Fig.2 shows the experimental results.

[0020]

The relationship between resistance (Ω) and load (g) was examined when the pressing part 10A of the presser 10 is spherical as shown in Fig.3 and when the pressing part 8A of the presser 8 is flat as shown in Fig.4. The spherical pressing part 10A obviously yielded minor hysteresis in applying and removing pressure and has stable properties. Here, three different spherical pressing parts 10A (radius = 2.5, 5, and 10) and two different flat pressing parts 8A (diameter $\phi = 5$ and 10) were used. The electrodes 4 of the substrate 1 used had an electro-conductive body width of 0.3 mm and a pitch of 0.6 mm.

[0021]

The above experiment showed that a presser having a spherical pressing part yields stable properties.

[0022]

[Efficacy of the invention]

As described above, in the present invention, a plate of electro-conductive rubber is used to improve durability. A presser having a spherical pressing part serves to concentrate the applied pressure stress in applying and removing pressure and prevents stress from escaping around the presser, yielding stable changes in resistance.

[Brief explanation of the drawings]

[Fig.1] A cross-sectional view of an embodiment of the present invention.
[Fig.2] A graphical representation of the same.
[Fig.3] A cross-sectional view of a test piece.
[Fig.4] A cross-sectional view of a test piece according to the prior art.
[Fig.5] A cross-sectional view of a prior art.

[Legend]

1 ... substrate, 4 ... electrode, 7 ... pressure-sensitive electro-conductive rubber (electro-conductive rubber), 10 ... presser, 10A ... pressing part

[Fig.1]

1 ... substrate
4 ... electrode
7 ... pressure-sensitive electro-conductive rubber (electro-conductive rubber)
10 ... presser
10A ... pressing part

[Fig.2]

ordinate: resistance (Ω);
abscissa: load (g)
depressuring
pressuring

[Fig.3]
[Fig.4]
[Fig.5]

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25401, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Patent Application H05-190051
"Pressure-sensitive switch"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

Roger P. Lewis

ROGER P. LEWIS

September 26, 2006

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Ｈ０１Ｈ　13/20		4235－5G		
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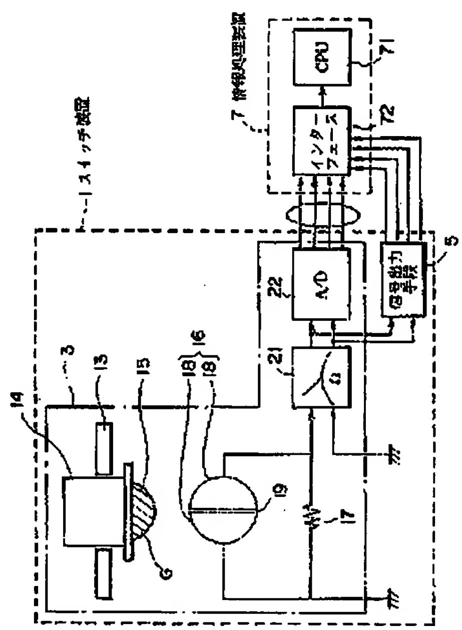
(54)【発明の名称】 スイッチ装置

(57)【要約】
【目的】 多くの情報をコマンド選択なしに与えられるスイッチ装置の提供。
【構成】 スイッチ装置１は、スイッチの操作量と操作時間に応じた電気信号を出力でき、該電気信号を情報処理装置７に与える。スイッチ装置１は操作されたときに操作量に関する信号を形成するスイッチ３と、スイッチ３の操作量に関する信号から操作時間に関する信号に変換する信号出力手段５とからなる。スイッチ３のカバー１３にはボタン１４が上下動可能に固定されている。ボタン１４は下端部に可動接点１５が固定され、コイルばね等で常時上側に付勢される。可動接点１５は一定の抵抗値を持つ導電性ゴムＧからなる。可動接点１５に対向して半円状導体１８，１８が間隙１９をおいて配設され、全体として円板状になっている。両円状導体１８間の抵抗の変化が操作量に関する信号としてスイッチ３から出力され、また信号出力手段３から操作時間に関する信号が出力される。



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【特許請求の範囲】

【請求項１】 操作された際に当該操作量に関する信号を出力できるスイッチと、このスイッチの操作量に関する信号から操作時間に関する電気信号を出力する信号出力手段と、を備えるスイッチ装置。

【請求項２】 前記スイッチは、操作用のボタンに固定した導電性ゴムからなる可動接点と、前記可動接点に対向する位置に導体を間隙を持たせて円形状に配置した固定接点と、前記導体の固定接点からの抵抗値を計測する抵抗測定器と、前記抵抗測定器からのアナログ量をデジタル信号に変換してＡ／Ｄ変換器とを備える請求項１記載のスイッチ装置。

【請求項３】 前記スイッチは、操作用のボタンに固定した可動磁石と、前記可動磁石に対向する位置に固定したコイル状の導線からなる固定コイルと、前記固定コイルで発生する電圧を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するＡ／Ｄ変換器とを備える請求項１記載のスイッチ装置。

【請求項４】 前記スイッチは、操作用のボタンに固定した可動電極と、前記可動電極に対向する位置に固定した固定電極と、前記両電極に電荷を与える手段と、前記両電極の静電容量に応じた電圧を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するＡ／Ｄ変換器とを備える請求項１記載のスイッチ装置。

【請求項５】 前記信号出力手段は、前記スイッチからの操作量に関するアナログ信号を基に操作時間に関するデジタル信号に変換する操作時間検出回路を備える請求項１、２、３または４記載のスイッチ装置。

【請求項６】 前記操作時間検出回路は、前記スイッチからの操作量に関するアナログ信号が所定値以上となったことを検出するコンパレータと、前記アナログ信号が最大値となったことを検出する最大値検出回路と、前記コンパレータの出力信号でセットされ前記最大値検出回路のリセットされるフリップフロップ回路と、前記フリップフロップ回路の出力で起動停止をするタイマーとを備える請求項５記載のスイッチ装置。

【請求項７】 前記スイッチは、操作用のボタンに固定した台形状の導電性ゴムからなる可動接点と、前記可動接点に対向する位置に一定間隔で複数の電極を配置してなる固定接点とを備え、各電極に接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるように構成する請求項１記載のスイッチ装置。

【請求項８】 前記スイッチは、ボタンに固定した半球状の導電性ゴムからなる可動接点と、前記可動接点に対向する位置であって、中心位置に中心電極を設け、その中心電極に対して一定間隔で複数の電極を円環状に配置してなる固定接点とを備え、各電極に接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるようにする請求項１記載のスイッチ装置。

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【請求項９】 前記信号出力手段は、前記操作量に関するデジタル量を基に操作時間に関するデジタル信号に変換する操作時間検出回路を備える請求項１、７または８記載のスイッチ装置。

【請求項１０】 前記操作時間検出回路は、操作量に関するデジタル量を基に操作時間に関するデジタル信号に変換する情報処理装置から構成する請求項１記載のスイッチ装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明はスイッチ装置に係わり、特にゲーム機に使用されるスイッチ装置に関するものである。さらに詳しくは、ゲーム機のコントロールパネルに設けられ、表示装置の画面上に表示されるキャラクターの動作を制御するための押しボタンスイッチ等に応用できるスイッチ装置に関するものである。

【０００２】

【従来の技術】この種のスイッチ装置としては、例えば、特開昭63-29113号公報に記載のものが存在する。この従来のスイッチ装置はマウス装置に関するものであり、指で押し下げることができるボタンと、このボタンが押される力によって異なる値のアナログ信号を出力する圧力センサと、前記アナログ信号をデジタル信号に変換するＡ／Ｄ変換器とを備え、ボタンの押す力が弱い場合は小さな値のデジタルデータを出力し、ボタンを押す力が強い場合は大きい値のデジタルデータを出力するように構成されている。

【０００３】そして、前記スイッチ装置では、ボタンのオン・オフに対応する情報に加え、ボタンを押す力の大小に対応する別な情報を情報処理装置に与えることができるため、情報処理装置は、前記各情報に基づいて各種の処理を実行することができる。

【０００４】

【発明が解決しようとする課題】前記スイッチ装置では、上述したようにオン・オフに関する情報及び押圧力に関する情報を情報処理装置に与えることができるが、さらに他の情報を与えようとすると、情報処理装置の表示装置の画面上で別なコマンドを与えて選択した後にボタンを押下操作しなければならないという不便があるとともに、与えることができる情報もスイッチのオン・オフとボタンの押圧力に関するものに限定されるという問題点がある。

【０００５】また、情報処理装置の一つであるゲーム機では、コントロールパネルに設けられたボタンを操作して、画面に表示されたキャラクターの動作を制御するものであるが、ボタンの押圧力の大小に基づいてキャラクターの動作を制御するだけでは、そのキャラクターの動作態様が限定的にならざるを得ないという問題点があ

り、ボタンを押すスピードに応じてキャラクターの動作をさせることが要求されていた。

【0006】そこで、この発明は、このような問題点を解決するために、さらに多くの情報をコマンドの選択することなしに与えることができるスイッチ装置を提供することを目的としている。

【0007】

【課題を解決するための手段】前記目的を達成するために、この発明に係わるスイッチ装置は、操作された際に当該操作量に関する信号を出力できるスイッチと、このスイッチの操作量に関する信号から操作時間に関する電気信号を出力する信号出力手段と、を備えたことを特徴とするものである。

【0008】この発明に係わるスイッチ装置のスイッチは、操作用のボタンに固定した導電性ゴムからなる可動接点と、前記可動接点に対向する位置に導体を間隙を持たせて円形状に配置した固定接点と、前記導体の固定接点からの抵抗値を計測する抵抗測定器と、前記抵抗測定器からのアナログ量をデジタル信号に変換してA／D変換器とからなることを特徴とするものである。

【0009】また、この発明に係わるスイッチ装置のスイッチは、操作用のボタンに固定した可動磁石と、前記可動磁石に対向する位置に固定したコイル状の導線からなる固定コイルと、前記固定コイルで発生する電圧を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するA／D変換器とからなることを特徴とするものである。

【0010】また、この発明に係わるスイッチ装置のスイッチは、操作用のボタンに固定した可動電極と、前記可動電極に対向する位置に固定した固定電極と、前記両電極に電荷を与える手段と、前記両電極の静電容量に応じた電圧を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するA／D変換器とからなることを特徴とするものである。

【0011】また、この発明に係わるスイッチ装置の信号出力手段は、前記スイッチからの操作量に関するアナログ信号を基に操作時間に関するデジタル信号に変換する操作時間検出回路からなることを特徴とするものである。

【0012】また、この発明に係わるスイッチ装置の操作時間検出回路は、前記スイッチからの操作量に関するアナログ信号が所定値以上となったことを検出するコンパレータと、前記アナログ信号が最大値となったことを検出する最大値検出回路と、前記コンパレータの出力信号でセットされ前記最大値検出回路のリセットされるフリップフロップ回路と、前記フリップフロップ回路の出力で起動停止するタイマーとからなることを特徴とするものである。

【0013】また、この発明に係わるスイッチ装置の前記スイッチは、操作用のボタンに固定した台形状の導電性ゴムからなる可動接点と、前記可動接点に対向する位置に一定間隔で複数の電極を配置してなる固定接点とを備え、各電極に接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるように構成したことを特徴とするものである。

【0014】また、この発明に係わるスイッチ装置のスイッチは、ボタンに固定した半球状の導電性ゴムからなる可動接点と、前記可動接点に対向する位置であって、中心位置に中心電極を設け、その中心電極に対して一定間隔で複数の電極を円環状に配置してなる固定接点とを備え、各電極に接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるようにしたことを特徴とするものである。

【0015】また、この発明に係わるスイッチ装置の信号出力手段は、前記操作量に関するデジタル量を基に操作時間に関するデジタル信号に変換する操作時間検出回路からなることを特徴とするものである。

【0016】また、この発明に係わるスイッチ装置の操作時間検出回路は、操作量に関するデジタル量を基に操作時間に関するデジタル信号に変換する情報処理装置から構成したことを特徴とするものである。

【0017】

【作用】本発明では、操作用のスイッチを操作すると、その操作に応じた信号がスイッチで形成される。このスイッチの操作量を後段の処理装置に与える。また、前記信号出力手段は、前記スイッチの操作量を基に操作時間に応じて電気信号となって出力される。このスイッチ装置からの操作量と操作時間とに応じた電気信号により、例えばゲーム機のキャラクターの移動量、移動速度等を制御することができる。

【0018】ここで、スイッチは、導電性ゴムからなる可動接点が、二つの導体を絶縁して円板状に配置した固定接点に接触してゆくとき、導電性ゴムが変形して二つの導体間の抵抗値が変化するので、これを電圧値に変換してスイッチの操作量の信号とし、かつ前記スイッチの操作量に関する信号を基に信号出力手段により操作速度の情報をもつ電気信号にしている。

【0019】また、スイッチは、可動磁石が固定コイルに接近するときに右ネジの法則により前記固定コイルに電圧が発生する。この電圧は、スイッチの操作量に関する電気信号とされ、かつ信号出力手段において操作速度の情報をもつ電気信号にしている。

【0020】さらに、スイッチは、可動電極と、固定電極と、電荷供給手段とで構成し、可動電極と固定電極の面積をSとし、両電極の距離をdとし、かつ両電極間の誘電率をεとすると、静電容量Cは、$C=\varepsilon S/d$で与えられことを利用し、ボタンの操作で両電極間の距離dが変化して静電容量Cが変化することを、信号出力手段で電圧に変化させ、スイッチの操作量、操作速度の情報をもつ電気信号にしている。

【0021】また、信号出力手段は、操作時間検出回路からなり、操作時間検出回路は、前記スイッチからの操作量に関するアナログ信号を基に操作時間に関するデジタル信号に変換することができる。

【0022】この際に、操作時間検出回路は、コンパレータにより前記スイッチからの操作量に関するアナログ信号が所定値以上となったことを検出してフリップフロップ回路をセットし、また前記アナログ信号が最大値となったことを最大値検出回路で検出してフリップフロップ回路回路をリセットする。これにより、アナログ信号の前半の立ち上がりを検出でき、この期間をタイマーで計数することにより、操作時間を検出できる。

【0023】また、前記スイッチでは、台形状の導電性ゴムからなる可動接点が、前記可動接点に対向する位置に一定間隔で複数の電極を配置してなる固定接点に接触するときに、導電性ゴムが変形して各電極に接触する。これにより、各電極に対する前記導電性ゴムの接触面積が変化する。この変化量は、単に接触したしないという信号となるが、複数の電極の接触関係のデジタル信号として出力できることになる。

【0024】加えて、前記スイッチでは、半球状の導電性ゴムからなる可動接点が、中心位置に中心電極を設け、その中心電極に対して一定間隔で複数の電極を円環状に配置してなる固定接点に接触し、導電性ゴムが変形して中心電極から順次外側の電極に向かって接触してゆくことになる。各電極に接触する前記導電性ゴムの接触は接触したしないという情報であるが、複数の電極があるため、導電性ゴムの接触面積に応じたデジタル量となる。

【0025】また、信号出力手段は操作時間検出回路からなり、操作時間検出回路は、前記操作量に関するデジタル量を基に操作時間に関するデジタル信号に変換することができる。

【0026】また、操作時間検出回路はコンピュータ等の情報処理装置で構成してもよく、操作量に関するデジタル量を基にソフトウエアによって操作時間に関するデジタル信号を得るようにしてもよい。

【0027】

【実施例】次に、本発明の実施例を図面に基づいて説明する。

<第1の実施例>図1は、本発明のスイッチ装置の実施例が接続された情報処理装置を示す構成図である。

【0028】図1に示すスイッチ装置1は、スイッチの操作量と操作時間に応じた電気信号を出力できるように構成されている。このスイッチ装置1は、情報処理装置3に電気的に接続されており、前記スイッチの操作量と操作時間に応じた電気信号を情報処理装置3に供給できるようになっている。

【0029】このスイッチ装置1は、操作されたときに、操作量に応じて電気信号を出力するスイッチ3と、前記スイッチ3からの操作量に応じた電気信号から操作時間に関する信号を得る信号出力手段5とからなる。

【0030】ここで、前記スイッチ3は、カバー13、ボタン14、可動接点15、固定接点16、抵抗17からなる機構系と、抵抗測定器21、A／D変換器22とからなる電気系とを具備している。

【0031】前記スイッチ3の機構系は次のように構成されている。カバー13は、スイッチ3の本体を構成する器枠である。このカバー13にはボタン14が図示上下動可能に固定されている。このボタン14は、図示上端部が操作端であり、下端部に可動接点15が固定されており、図示しないコイルばね等で図示上側に常時付勢されている。可動接点15は半球状の導電性ゴムGからなる。この導電性ゴムGは一定の抵抗値を持っている。この可動接点15に対向した位置には、半円状導体18、18が間隙19を持たせて配設されており、半円状導体18，18が全体として円板状になるように配置されている。前記半円状導体18，18には、抵抗17が並列接続されており、抵抗17の一端が接地され、抵抗17の他端が信号出力手段12の抵抗測定器21の入力端子の一端に接続されている。

【0032】また、スイッチ3の電気系は、次のように構成されている。抵抗測定器21は、その入力端子の一端に抵抗17の他端を接続し、その入力端子の他端を接地しており、半円状導体18，18間の抵抗値の変化と速度を検出できるようになっている。前記抵抗測定器21の出力端は、A／D変換器22に接続されている。A／D変換器22は、抵抗測定器21からの抵抗値及び単位時間当たりの抵抗値の変化量をデジタル信号に変換するようになっている。

【0033】また、前記信号出力手段5の入力端子には抵抗測定器21の出力端子が接続されており、抵抗測定器21から前記ボタン14の操作量に応じたアナログ電気信号が入力されるようになっている。信号出力手段5は、操作量に応じたアナログ電気信号を基に操作時間に関するデジタル信号にし、これを出力端子から出力できるようになっている。信号出力手段5の出力端子は、情報処理装置7のインターフェース72に接続されており、操作時間に関するデジタル信号をインターフェース72を介してCPU71に供給できるようになっている。

【0034】また、スイッチ3のA／D変換器22は、デジタル信号をパラレル信号として出力するようになっている。このA／D変換器22のパラレル出力端子は、情報処理装置7のインターフェース72にパラレル入出力端子に接続されている。

【0035】前記情報処理装置3は、この実施例では、CPU71、及びインターフェース72のみを表示しているが、ROM、RAM、I／O装置、表示装置、外部記憶装置、その他処理に必要な各種要素を備えている。

【０036】図2は、信号出力手段5の具体的回路構成例を示すブロック図である。図2において、信号出力手段5は操作時間検出回路５１からなり，次のように構成されている。操作時間検出回路５１は，コンパレータ５２，最大値検出回路５３，フリップフロップ回路５４，タイマー５５とを備えている。前記抵抗測定器２１の出力端子は、コンパレータ５２及び最大値検出回路５３の各入力端子に接続されており、抵抗電圧変換回路１からのアナログ操作量信号が供給されるようになっている。コンパレータ５２の出力端子Sは、フリップフロップ回路５４のセット端子に接続されている。最大値検出回路５３の出力端子は、フリップフロップ回路５４のリセット端子Rに接続されている。また、フリップフロップ回路５４のクロック端子ＣＰには動作用クロックが入力されている。フリップフロップ回路５４の非反転出力端子Qはタイマー５５の起動停止制御端子に接続されており，出力端子Qが“1”のときのみにタイマー５５が起動するようにしてある。また、フリップフロップ回路５４の反転出力端子ＲＱは最大値検出回路５３のリセット端子に接続されている。

【００３７】また、タイマー５５は，例えば次のように構成すればよい。タイマー５５は、基準クロック発生回路５５１と、ゲート回路５５２と、カウンタ５５３とからなり，フリップフロップ回路５４の非反転出力端子Qの出力信号をゲート回路５５２の一方の入力端子に接続し，ゲート回路５５２の他方に入力端子に基準クロック＊発生回路５５１の出力端子を接続し，ゲート回路５５３の出力端子をカウンタ５５３の入力端子に接続したものでよい。

【００３８】このように構成された実施例の動作を図１乃至図４を参照して説明する。なお，図3はスイッチ装置の操作に対応する抵抗値に関する特性が示されており，横軸に時間を、縦軸に抵抗値をとったものである。また，図４は，電圧値の変化に対する操作時間に関する信号の関係を示す図であり，横軸に時間を、縦軸の電圧の変化をとったものである。

【００３９】このように構成されたスイッチ装置１によれば，ボタン１４を図示しないコイルばねの付勢力に抗して押下すると，可動接点１５の導電性ゴムGが固定接点１６の半円状導体１８，１８に接触する。半円状導体１８，１８同士が可動接点１５の導電性ゴムGで接続し，抵抗１７の抵抗値より小さくなる。さらに，押下すると，可動接点１５の導電性ゴムGが固定接点１６の半円状導体１８，１８に接触しながら変形してゆく。これにより、可動接点１５の導電性ゴムGの接触面積が広がり，それに伴って抵抗値をもった導電性ゴムGの半円状導体１８，１８に対する接触抵抗が徐々に小さくなる。このような導電性ゴムGと半円状導体１８，１８との接触面積に対する抵抗測定器２１が計測する抵抗値の関係の一例について示すと表１のようになる。

【００４０】

【表１】

スイッチの操作	操作なし	操作あり（ボタン14を押下した）			
接触面積	0cm²	1cm²	2cm²	3cm²	4cm²
合成抵抗Ro	R	R／2	R／3	R／4	R／5

【００４１】この表１において、合成抵抗Ｒｏは，抵抗１７と導電性ゴムGの接触抵抗による合成抵抗であり、また，抵抗／面積＝R／㎠ とする。

【００４２】このように変化する合成抵抗Ｒｏは抵抗測定器２１で計測される。このような合成抵抗Ｒｏの変化は，図3に示すようになる。図３（ａ）では操作量が小さくかつ操作速度が遅い場合の例であり、合成抵抗Ｒｏの変化△Ｒａが小さく、かつ操作時間△ｔａが長い例を示している。また、図３（ｂ）では操作量が大きくかつ操作速度が早い場合の例であり、合成抵抗Ｒｏの変化△Ｒｂが大きく，かつ操作時間△ｔｂが短い例を示している。さらに、図３（ｃ）では操作量が大きくかつ操作速度が早い場合の例であり，合成抵抗Ｒｏの変化△Ｒｃが大きく、かつ操作時間△ｔｃが短い例を示している。

【００４３】このような合成抵抗Ｒｏの変化を抵抗測定器２１で計測すると、抵抗測定器２１は前記合成抵抗Ｒｏの抵抗値の変化に応じた電圧を発生する。このアナログ信号には、合成抵抗Ｒｏの変化の情報として，抵抗値の変化量△Ｒと，その変化の時間△ｔと、その変化の極分値との情報が電圧信号に含まれることになる。この抵抗測定器２１からの出力電圧は、Ａ／Ｄ変換器２２でデジタル信号に変換される。

【００４４】一方、前記抵抗測定器２１から出力されるアナログ信号は，コンパレータ５２及び最大値検出回路５３に入力される。コンパレータ５２では，アナログ信号が所定の基準電圧Ｅｏを超えると“1”を出力する。このコンパレータ５２の出力が“1”になると，フリップフロップ回路５４はセットされて，フリップフロップ回路５４から“1”が出力される。これにより，タイマー５５が起動する。すなわち、ゲート回路５５２が開

き、基準クロック発生回路551から基準クロックがカウンタ553に供給される。カウンタ553は、これを計数する。そして、最大値検出回路53は、入力されているアナログ信号を監視しており、直前に入力された電圧より小さい電圧値を検出すると“1”を出力する。これにより、フリップフロップ回路54がリセットされることになる。フリップフロップ回路54の非反転出力端子Qからは“0”が出力されることになり、タイマー55が停止する。すなわち、ゲート回路552が閉じて、カウンタ553に基準クロックが入力されなくなる。これにより、カンウタ553には、アナログ信号の立ち上がり側の時間を計測できることになる。なお、この際にフリップフロップ回路54の反転出力端子RQから“1”が出力されるので、これを用いて最大値検出回路53をリセットし、次の最大値検出に備える。

【0045】このようにA／D変換器22で得られたデジタル信号と、信号出力手段5のタイマー55から得られたデジタル信号は、インターフェース72を介してCPU71に入力される。例えば、CPU71がゲーム機として使用されているときには、前記合成抵抗Roの抵抗値の変化量ΔRと、その抵抗値の変化時間Δtとを用いて、キャラクターを抵抗値の変化量ΔRに応じた距離移動させるとともに、変化時間Δtに応じてキャラクターを短時間あるいは長い時間かけて移動させたりすることができる。また、CPU71は前記合成抵抗Roの変化の積分値で例えばキャラクターが他のキャラクターに衝突したときに衝突の衝撃力の大きさ等を表現できる。

【0046】このように第1の実施例によれば、ボタン14の操作に関する情報が操作変化量、操作変化時間、操作量からなるので、複雑な処理をすることが可能になる利点がある。

【0047】<第2の実施例>図5は、同スイッチ装置の第2の実施例を情報処理装置に接続した例を示す構成図である。なお、この第2の実施例でも第1の実施例と同一構成要素には同一の符号を付して説明する。

【0048】図5に示すスイッチ装置1aにおいても、スイッチの操作量と操作時間に応じた電気信号を出力できるように構成されている。このスイッチ装置1aも、情報処理装置7に電気的に接続されており、前記スイッチの操作量と操作時間に応じた電気信号を情報処理装置7に供給できるようになっている。このスイッチ装置1aも、操作されたときに、操作量に応じて電気信号を出力するスイッチ3aと、前記スイッチ3aからの操作量に応じた電気信号から操作時間に関する信号を得る信号出力手段5aとからなる。

【0049】ここで、前記スイッチ3aは、カバー13、ボタン14、可動磁石15a、固定コイル16aを備え、次のように構成されている。カバー13は、スイッチ11aの本体を構成する外側の器枠であり、このカバー13にボタン14が図示上下動可能に固定されている。このボタン14は、図示下端部に可動磁石15aが固定されている点で第1の実施例と異なるが、図示しないコイルばね等で図示上側に常時付勢されている点では第1の実施例と同一である。なお、可動磁石15aは図示下方にN極が、図示上方向にS極が配置されるようにしている。もちろん、この逆でも差し支えない。この可動磁石15aに対向した位置には、固定コイル16aが配設されている。この固定コイル16aは、導線の外側が絶縁された絶縁電線を渦巻き状に巻いたり、あるいはコイル状に巻くことにより構成されている。この固定コイル16aの両端は、演算増幅器21aに両入力端子に接続されている。演算増幅器21aの出力端子は、A／D変換器22の入力端子に接続されている。演算増幅器21aは、非反転入力端子と反転入力端子に固定コイル16aの他端が接続されており、固定コイル16aに発生する電圧の変化と速度を増幅できるようになっている。前記演算増幅器21aの出力端は、A／D変換器22に接続されている。A／D変換器22は、演算増幅器21aからの電圧値の変化量をデジタル信号に変換するようになっている。このA／D変換器22は、デジタル信号をパラレル信号として出力するようになっている。このA／D変換器22のパラレル出力端子は、情報処理装置7のインターフェース72にパラレル入出力端子に接続されている。

【0050】また、信号出力手段5aの構成は、第1の実施例と全く同一の構成であるので説明を省略する。前記情報処理装置7も、第1の実施例と全く同様な構成であるので説明を省略する。

【0051】このようなスイッチ装置1aによれば、ボタン14の押下により、可動磁石15aが固定コイル16aに近つぎ、その速度に応じて右ネジの法則より固定コイル16aに電圧が発生する。この電圧は、ボタン14の押し下げる速度に比例して増減するので、その電圧の変化を演算増幅器21aで増幅し、A／D変換器22でデジタル信号にして情報処理装置7のインターフェース72を介してCPU71に与える。

【0052】信号出力手段5の操作時間検出回路51は、前記電圧の変化からボタン14の押圧速度に関するデジタル信号を得る。この操作時間に関するデジタル信号は、情報処理装置7のインターフェース72を介してCPU71に入力される。

【0053】情報処理装置7のCPU71は、前述した操作量及び操作時間に関するデジタル信号を用いて種々の処理を行なう。例えばゲーム機にCPU71が使用されているとすれば、前記第1の実施例と同様に処理がなされる。

【0054】上述した第2の実施例によれば、ボタン14の操作に関する情報が操作変化量、操作変化時間、操作量からなるので、複雑な処理をすることが可能になる。

【0055】＜第3の実施例＞図6は、同スイッチ装置の第3の実施例を情報処理装置に接続した例を示す構成図である。なお、この第3の実施例でも第1の実施例と同一構成要素には同一の符号を付して説明する。

【0056】図6に示すスイッチ装置1bにおいても、スイッチの操作量と操作時間に応じた電気信号を出力できるように構成されている。このスイッチ装置1bも、情報処理装置7に電気的に接続されており、前記スイッチの操作量と操作時間に応じた電気信号を情報処理装置7に供給できるようになっている。

【0057】このスイッチ装置1bは、操作されたときに、操作量に応じて電気信号を出力するスイッチ3aと、前記スイッチ3aからの操作量に応じた電気信号から操作時間に関する信号を得る信号出力手段5aとからなる点で第1の実施例と同様である。

【0058】ここで、前記スイッチ11bは、カバー13、ボタン14、可動電極15b、固定電極16bを備え、次のように構成されている。カバー13は、スイッチ11bの本体を構成する外側の容枠であり、このカバー13にボタン14が図示上下動可能に固定されている点で第1の実施例と同一である。このボタン14は、図示下端部に可動電極15bが固定されている点で第1の実施例と異なるが、図示しないコイルばね等で図示上側に常時付勢されている点では第1の実施例と同一である。この可動電極15bに対向した位置には、固定電極16bが配設されている。なお、前記可動電極15bと固定電極16bとは最終操作量まで押下しても接触しないようになっている。前記可動電極15bと固定電極16bには、図示しない直流電源から、可動電極15bがプラス極に固定電極16bがマイナス極に帯電されるように電荷が印加されている。この可動電極15bは信号出力手段12bの演算増幅器21bの例えば非反転端子に、固定電極16bは信号出力手段12bの反転端子にそれぞれ接続されている。演算増幅器21bの出力端子は、A／D変換器22に接続されている。演算増幅器21bは、非反転入力端子に可動電極15bが、反転入力端子に固定電極16bが接続されており、可動電極15bと固定電極16bの間隙の変化に応じた静電容量の変化と速度を電圧信号として増幅できるようになっている。前記演算増幅器21bの出力端は、A／D変換器22に接続されている。A／D変換器22は、演算増幅器21bからの静電容量値及び単位時間当たりの静電容量値の変化量の電圧信号をデジタル信号に変換するようになっている。このA／D変換器22は、デジタル信号をパラレル信号として出力するようになっている。このA／D変換器22のパラレル出力端子は、情報処理装置7のインターフェース72にパラレル入出力端子に接続されている。

【0059】また、信号出力手段5bは、前記第1の実施例と全く同一の構成である。また、信号出力手段5bの入力端子には、演算増幅器21bの出力端子が接続されており、信号出力手段5bの出力端子は情報処理装置7のインターフェース72のパラレル入力端子に接続されている。前記情報処理装置7は、第1の実施例と全く同様な構成であるので説明を省略する。

【0060】このようなスイッチ装置1bによれば、ボタン14の押下により、可動電極15bと固定電極16bとの距離が縮まり、静電容量が変化する。静電容量は、可動電極15bと固定電極16bとの距離の大きさに反比例して増減するので、その静電容量の変化を演算増幅器21bで電圧変化に変換し、この電圧をA／D変換器22でデジタル信号にする。このデジタル信号は、情報処理装置7のインターフェース72を介してCPU71に渡す。

【0061】また、信号出力手段5bでは、前記ボタン14の操作により静電容量の変化を判断し、ボタン14の速度等の操作動作の変化を計数してデジタル信号として出力する。

【0062】このような二つのデジタル信号は、情報処理装置7のインターフェース72を介してCPU71に与えられる。CPU71は種々の処理を行なう。例えばゲーム機にCPU71が使用されているとすれば、前記第1の実施例と同様に処理がなされる。

【0063】上述した第3の実施例によれば、ボタン14の操作に関する情報が操作変化量、操作変化時間、操作量からなるので、複雑な処理をすることが可能になる。

【0064】＜第4の実施例＞図7は、同スイッチ装置の第4の実施例を情報処理装置に接続した例を示す構成図である。なお、この第4の実施例でも第1の実施例と同一構成要素には同一の符号を付して説明する。

【0065】図7に示すスイッチ装置1cにおいても、スイッチの操作量と操作時間に応じた電気信号を出力できるように構成されている。このスイッチ装置1cも、情報処理装置7に電気的に接続されており、前記スイッチの操作量と操作時間に応じた電気信号を情報処理装置7に供給できるようになっている。

【0066】このスイッチ装置1cは、操作されたときに、操作量に応じて電気信号を出力するスイッチ3aと、前記スイッチ3aからの操作量に応じた電気信号から操作時間に関する信号を得る信号出力手段5aとからなる。

【0067】ここで、前記スイッチ3cは、次のように構成されている。すなわち、スイッチ装置1cは、カバー13、ボタン14、可動接点15c、固定接点16cを備えている。カバー13は、スイッチ装置1cの本体を構成する外側の容枠であり、このカバー13にボタン14が図示上下動可能に固定されている点で第1の実施例と同一である。このボタン14は、図示下端部に図示左側が図示右側より低い台形状をした導電性ゴムGで構

成した可動接点１５ｃが固定されている点で第１の実施例と異なるが、図示しないコイルばね等で図示上側に常時付勢されている点では第１の実施例と同一である。この可動設定１５ｃに対向した位置には、固定接点１６ｃが配設されている。この固定接点１６ｃは、複数の電極１６c1，１６c2，１６c3，１６c4，１６c5が一定間隔１９c1，１９c2，１９c3，１９c4を持たせて配設されている。これら電極１６c1は接地されており、４つの電極１６c2，１６c3，１６c4，１６c5は情報処理装置７のインターフェース７２に接続されている。これにより，４ビットのデジタル信号として出力される。また、インターフェース７２には、クロックＣＬＯＣＫが入力されている。

【００６８】図８は、信号出力手段５ｃの操作時間検出回路５１ｃの構成を示す回路図である。操作時間検出回路５１ｃは、例えば前記４ビットの場合には、３つの排他的論理和（ＥＸＯＲ）回路５６，５７，５８と，同３つのフリップフロップ回路５９，６０，６１と，同３つの論理積（ＡＮＤ）回路６２，６３，６４と、論理和（ＯＲ）回路６５と、タイマー５５とからなる。

【００６９】前記電極１６c2はＥＸＯＲ回路５６の一方の入力端子に接続されており、前記電極１６c3はＥＸＯＲ回路５６の他方の入力端子に接続されている。また、前記電極１６c3はフリップフロップ回路５９のリセット入力端子に接続されている。前記電極１６c3はＥＸＯＲ回路５７の一方の入力端子に接続されており、前記電極１６c4はＥＸＯＲ回路５７の他方の入力端子に接続されている。電極１６c4はフリップフロップ回路６０のリセット端子に接続されている。前記電極１６c4はＥＸＯＲ回路５８の一方の入力端子に接続されており、電極１６c5はＥＸＯＲ回路５８の他方の入力端子に接続されている。また、電極１６c5はフリップフロップ回路６１のリセット端子に接続されている。また，各フリップフロップ回路６１，６２，６３には図示しないがクロックがクロック端子に供給されており、また，タイマー６５の計数が終了した時点で各フリップフロップ回路６１，６２，６３の出力端子Ｑが“１”となるようにクリアできるようにしてある。前記各フリップフロップ回路５９，６０，６１の出力端子Ｑは各ＡＮＤ回路６２，６３，６４の他方の入力端子にそれぞれ接続されている。また、各ＥＸＯＲ回路５６，５７，５８の出力端子は，各ＡＮＤ回路６２，６３，６４の一方の入力端子にそれぞれ接続されている。各ＡＮＤ回路６２，６３，６４の出力端子は，ＯＲ回路６５の各入力端子にそれぞれ接続されている。ＯＲ回路６５の出力端子は、タイマー５５の起動停止制御端子に接続されている。なお，タイマー５５は，第１の実施例のものと全く同一であるので説明を省略する。また，前記情報処理装置７も，第１の実施例と同様な構成であるので説明を省略する。

【００７０】次に、前記第４実施例の動作を図６及び図７を参照して説明する。図７は、前記第４の実施例の動作を説明するためのタイミングチャートであり，横軸に時間を、縦軸に各部の信号を示している。

【００７１】このように構成されたスイッチ装置１によれば，ボタン１４を図示しないコイルばねの付勢力に抗して押下すると，可動接点１５ｃの導電性ゴムＧが固定接点１６ｃの電極１６c1に接触する。さらに押下されると，電極１６c1，１６c2が可動接点１５ｃの導電性ゴムＧが変形することにより接続される。さらに、押下すると，可動接点１５ｃの導電性ゴムＧが固定接点１６ｃの電極１６c1，１６c2，１６c3に接触しながら変形してゆく。このようにして可動接点１５ｃの導電性ゴムＧの接触面積が広がり，それに伴って電極１６c1，１６c2，１６c3，１６c4，１６c5が徐々に接地されてゆく。このような導電性ゴムＧと電極１６c1，１６c2，１６c3，１６c4，１６c5の接続関係がボタン１４の押下力と押下速度で変化する。このような固定接点１６ｃの電極１６c1，１６c2，１６c3，１６c4，１６c5の接続関係は，直接情報処理装置７のインターフェース７２に入力されて、ＣＰＵ７１に与えられる。

【００７２】次に、フリップフロップ回路５９，６０，６１は出力端子Ｑが“１”となるように初期設定されているものとする。ここで，例えば電極１６c1，１６c2が接触すると、スイッチ３の電極１６c2が“０”となる（図９（ａ）参照）。この信号がスイッチ装置１の出力信号として出力されるが，信号出力手段５では，ＥＸＯＲ回路５６において全く条件が成立しないためタイマー５５が動作せず，タイマー５５からは操作時間に関するデジタル信号は出力されない。

【００７３】次に、例えば電極１６c1，１６c2，１６c3が所定の時間でもって接触すると、電極１６c2，１６c3がそれぞれ“０”となる（図９（ｂ）参照）。これがスイッチ装置１のスイッチ３の出力信号として情報処理装置７に入力される。

【００７４】一方、前記信号出力手段５では、時刻ｔ１～ｔ２と、時刻ｔ３～ｔ４においてＥＸＯＲの条件が成立して、ＥＸＯＲ回路５６からは、図９（ｂ）に示すように，時刻ｔ１～ｔ２と，時刻ｔ３～ｔ４において“１”が出力される。しかし、時刻ｔ２においてフリップフロップ回路５９が“０”となるため、ＡＮＤ回路６２の出力端子からは，時刻ｔ３～ｔ４における“１”が出力されず，結局時刻ｔ１～ｔ２の“１”のみが出力されることになる。この“１”は，ＯＲ回路６５を介してタイマー５５の起動停止制御端子に入力される。これにより，時刻ｔ１～ｔ２の間の時刻が計数できることになる。

【００７５】さらに，例えば電極１６c1，１６c2，１６c3，１６c4が所定の時間でもって接触すると、電極１６c2，１６c3，１６c4がそれぞれ“０”となる（図９（ｃ）参照）。これがスイッチ装置１のスイッチ３の出

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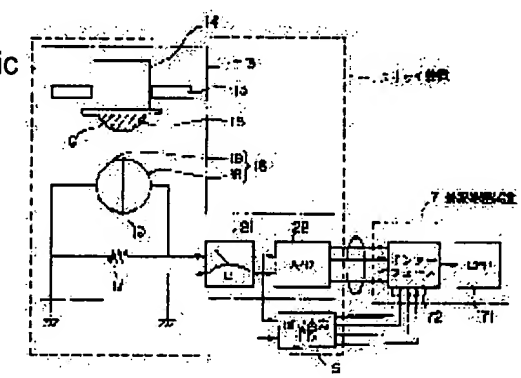
(54) SWITCH DEVICE

(57)Abstract:

PURPOSE: To provide the switch device from which lots of information is provided without selection of commands.



CONSTITUTION: The switch device 1 outputs an electric signal depending on a switch manipulated variable of a switch and its operation time and the electric signal is given to an information processing unit 7. The switch device 1 is made up of a switch 3 generating a signal related to a manipulated variable when in operation and a signal output means 5 for converting the signal of the manipulated variable of the switch 3 into a signal related to its operation time. A button 14 is fixed movably vertically to a cover 13 of the switch 3 a movable contact 15 is fixed to a lower end of the button 14 and always energized to an upper position by a coil spring or the like. Semi-circular conductors 18 are arranged at a gap 19 opposite the movable contact 15 made of a conductive rubber G having a prescribed resistance and they form a disk as a whole. Then a change in the resistance between both the semicircular conductors 18 is outputted from the switch 3 as a signal related to the manipulated variable and the signal output means 5 outputs a signal relating its operation time.

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力信号として情報処理装置７に入力される。

【００７６】一方、信号出力手段５では、ＥＸＯＲ回路５６は時刻ｔ11～ｔ12と、時刻ｔ15～ｔ16においてＥＸＯＲの条件が成立し、ＥＸＯＲ回路５７は時刻ｔ12～ｔ13と、時刻ｔ14～ｔ15においてＥＸＯＲの条件が成立するので、ＥＸＯＲ回路５６からは、図９（ｃ）に示すように、時刻ｔ11～ｔ12と、時刻ｔ15～ｔ16において“１”が出力され、ＥＸＯＲ回路５７からは、図９（ｃ）に示すように、時刻ｔ12～ｔ13と、時刻ｔ14～ｔ15において“１”が出力される。しかし、時刻ｔ14においてフリップフロップ回路６０の出力端子Ｑが“０”となるため、ＡＮＤ回路６３の出力端子からは、時刻ｔ14～ｔ15における“１”が出力されず、結局時刻ｔ12～ｔ13の“１”のみが出力されることになる。また、時刻ｔ15においてフリップフロップ回路５９の出力端子Ｑが“０”となるため、ＡＮＤ回路６２の出力端子からは、時刻ｔ15～ｔ16における“１”が出力されず、結局時刻ｔ11～ｔ12の“１”のみが出力されることになる。これらの“１”がＯＲ回路６５に入力されると、ＯＲ回路６５の出力端子からは時刻ｔ11～ｔ13までが“１”となる信号が得られる。この信号は、タイマー５５の起動停止制御端子に入力する。これにより、時刻ｔ11～ｔ12の間の時刻が計数できることになる。

【００７７】加えて、例えば電極１６ｃ1、１６ｃ2、１６ｃ3、１６ｃ4、１６ｃ5が所定の時間でもって接触すると、電極１６ｃ2、１６ｃ3、１６ｃ4、１６ｃ5がそれぞれ“０”となる（図９（ｄ）参照）。これがスイッチ装置１のスイッチ３の出力信号として情報処理装置７に入力される。一方、前記信号出力手段５では、ＥＸＯＲ回路５６は時刻ｔ21～ｔ22と、時刻ｔ27～ｔ28においてＥＸＯＲの条件が成立し、ＥＸＯＲ回路５７は、時刻ｔ22～ｔ23と、時刻ｔ26～ｔ27においてＥＸＯＲの条件が成立し、ＥＸＯＲ回路５８は、時刻ｔ23～ｔ24と、時刻ｔ25～ｔ26においてＥＸＯＲの条件が成立するので、ＥＸＯＲ回路５６からは、図９（ｄ）に示すように、時刻ｔ21～ｔ22と、時刻ｔ27～ｔ28において“１”が出力され、ＥＸＯＲ回路５７からは、図９（ｃ）に示すように、時刻ｔ22～ｔ23と、時刻ｔ26～ｔ27において“１”が出力され、ＥＸＯＲ回路５８からは、図９（ｄ）に示すように、時刻ｔ23～ｔ24と、時刻ｔ25～ｔ26において“１”が出力される。しかし、時刻ｔ25においてフリップフロップ回路６１の出力端子Ｑが“０”となるため、ＡＮＤ回路６４の出力端子からは、時刻ｔ25～ｔ26における“１”が出力されず、結局時刻ｔ23～ｔ24の“１”のみが出力されることになる。また、時刻ｔ25においてフリップフロップ回路６０の出力端子が“０”となるため、ＡＮＤ回路６３の出力端子からは、時刻ｔ26～ｔ27における“１”が出力されず、結局時刻ｔ23～ｔ24の“１”のみが出力されることになる。また、時刻ｔ27においてフリップフロップ回路５９の出力端子Ｑが“０”となるため、ＡＮＤ回路６２の出力端子からは、時刻ｔ27～ｔ28における“１”が出力されず、結局時刻ｔ21～ｔ22の“１”のみが出力されることになる。これらの“１”がＯＲ回路６５に入力されると、ＯＲ回路６５の出力端子からは時刻ｔ21～ｔ24までが“１”となる信号が得られる。この信号は、タイマー５５の起動停止制御端子に入力する。これにより、時刻ｔ21～ｔ24の間の時刻が計数できることになる。このようにして得られた操作時間に関するデジタル信号は、情報処理装置７のＣＰＵ７１に与えられる。

【００７８】ＣＰＵ７１は、前記固定接点１６ｃの電極１６ｃ1、１６ｃ2、１６ｃ3、１６ｃ4、１６ｃ5の接地（接続）関係の変化と、信号出力手段５からの操作時間に関する信号とを基に各種の処理を実行する。

【００７９】このような第４の実施例では、前記第１の実施例と同様な作用効果を奏する他、ボタン１４の操作情報が直接デジタル信号として得ることができるので、抵抗測定器、演算増幅器あるいはＡ／Ｄ変換器等を不要とすることができる利点がある。

【００８０】＜第５の実施例＞図１０は、同スイッチ装置の第５の実施例を情報処理装置に接続した例を示す構成図である。なお、この第５の実施例でも第１の実施例と同一構成要素には同一の符号を付して説明する。

【００８１】図１０に示すスイッチ装置１ｄは図５のスイッチ装置１ｃの変形例であり、第１の実施例及び第４の実施例と同様にスイッチの操作量と操作時間に応じた電気信号を出力できるように構成されている。このスイッチ装置１ｄも、情報処理装置７に電気的に接続されており、前記スイッチの操作量と操作時間に応じた電気信号を情報処理装置７に供給できるようになっている。このスイッチ装置１ｄは、操作された際に当該操作量に関する信号を出力できるスイッチ３ｄと、このスイッチの操作量に関する信号から操作時間に関する電気信号を出力する信号出力手段５ｄとを備えている。

【００８２】ここで、前記スイッチ３ｄは、カバー１３、ボタン１４、可動接点１５ｄ、固定接点１６ｄを備えている点で第４の実施例と同様である。前記カバー１３にボタン１４が図示上下動可能に固定されている点で第１の実施例と同一である。このボタン１４は、図示下端部に図示半球状をした導電性ゴムＧで構成した可動接点１５ｄが固定されており、かつ図示しないコイルばね等で図示上側に常時付勢されている点で第１の実施例と同一である。この可動設定１５ｄに対向した位置には、固定接点１６ｄが配設されている。この固定接点１６ｄは、中心電極１６ｄ1の周囲に対して、複数の電極１６ｃ2、１６ｃ3、１６ｃ4、１６ｃ5が一定間隔１９ｄ1、１９ｄ2、１９ｄ3、１９ｄ4を持たせて円形状に配設されている。これら電極１６ｄ1は接地されており、電極１６ｄ2、１６ｄ3、１６ｄ4、１６ｄ5は情報処理装置３のインターフェース３２に直接接続されている。また、インターフェ

ース32には、クロックCLOCKが入力されている。

【0083】また、信号出力手段5dは、第4の実施例のものと全く同一のものであるので、説明を省略する。さらに、前記情報処理装置7も、第1の実施例と同様な構成であるので説明を省略する。

【0084】このように構成されたスイッチ装置1dによれば、ボタン14を図示しないコイルばねの付勢力に抗して押下すると、可動接点15dの導電性ゴムGが固定接点16dの電極$16d_1$に接触する。さらに押下されると、電極$16d_1$、$16d_2$が可動接点15cの導電性ゴムGが変形することにより接続される。さらに、押下すると、可動接点15dの導電性ゴムGが固定接点16dの電極$16d_1$、$16d_2$、$16d_3$に接触しながら変形してゆく。このようにして可動接点15cの導電性ゴムGの接触面積が広がり、それに伴って電極$16d_1$、$16d_2$、$16d_3$、$16d_4$、$16d_5$が徐々に接地されてゆく。このような導電性ゴムGと電極$16d_1$、$16d_2$、$16d_3$、$16d_4$、$16d_5$の接続関係がボタン14の押下力と押下速度で変化する。このような固定接点16dの電極$16d_1$、$16d_2$、$16d_3$、$16d_4$、$16d_5$の接続関係は、直接情報処理装置7のインターフェース72に直接入力されて、CPU71に与えられる。

【0085】また、信号出力手段5dは、前記スイッチの操作時間の変化を計時しており、その計時された信号を情報処理装置7のCPU71に与える。

【0086】CPU71は、前記固定接点16dの電極$16d_1$、$16d_2$、$16d_3$、$16d_4$、$16d_5$の接地（接続）関係の変化、及び信号出力手段5dからの操作時間に関する信号を取込み、種々の処理に役立てる。

【0087】このような第5の実施例では、前記第1の実施例と同様の作用効果を奏する他、ボタン14の操作情報が直接デジタル信号として得ることができるので、抵抗測定器、演算増幅器あるいはA／D変換器等を不要とすることができる利点がある。

【0088】＜第6の実施例＞図11は、本発明の第6の実施例を示すブロック図である。この第6の実施例は、第1の実施例から信号出力手段5を削除し、信号出力手段5を情報処理装置9で構成したものである。なお、情報処理装置9は、CPU91と、インターフェース92とからなる。

【0089】CPU91は、スイッチ3から出力されるデジタル信号を取込み、合成抵抗Roの抵抗値の変化を電圧値で記憶し、これらの情報から、抵抗値の変化ΔRと、抵抗値の変化時間Δtと、抵抗値の変化の積分値とを判断する。これは、次のようにして判断する。CPU91は、合成抵抗Roを一定時間間隔で取り込んでいるので、一つ前の取込み時間における抵抗値と現取り込み時間における抵抗値とを比較し、現取込み時間における抵抗値が大きくなったときに、前の取込み時間の抵抗値が最小値になったと判断する。そして、CPU91は、

前記判断から、抵抗値の変化の最初から抵抗値が最小値になったときまでの時間Δtと抵抗値の変化分ΔRとを求めるとこができる。また、CPU91は、前記各取込み時間における抵抗値の全部を加算することにより合成抵抗Roの変化分の積分値を得ることができる。このようにした求めた合成抵抗Roの変化分ΔRと変化時間Δtと変化の積分値をCPU91は他の情報処理装置7に与えることができる。もちろん、情報処理装置7と情報処理装置9とを兼用するようにしてもよい。

【0090】上述したような各スイッチ装置の実施例は、次のように分野に応用することができる。

【0091】前記各スイッチ装置は、ジョイパッドに応用することができる。この場合、パッドのボタンを押下されたときの強さをいくつかの基準値と比較し、そのボタンの入力状態を判別して、格闘ゲームの攻撃の強弱、スポーツゲームの投げる、蹴る等の強弱や速度を調整するように応用すればよい。

【0092】また、前記各スイッチ装置は、ユーザー判別キーボートに応用することができる。ユーザーのキータッチの仕方等をパーソナルコンピュータに学習させ、基準値とする。キータッチがあるたびに前記基準値と比較し、その差が大きいときにはユーザー以外であると判断し、パーソナルコンピュータはロック又はリセット等を実行するように応用してもよい。ここで使用するキータッチのデータとしては、キーを押下する速度等とする。

【0093】さらに、前記各スイッチ装置は、キーボードに応用することができる。このようにキーボードに応用した場合には、ユーザーのキータッチの強さを基に基準値を作成してコンピュータに記憶させておき、ユーザーのキータッチの強さを基準値と比較し、強いときには大文字、弱いときには小文字とし、あるいは強いときにはページ単位、弱いときには行単位でカーソルのアップ、ダウンをするように応用してもよい。

【0094】また、前記各スイッチ装置は、時計の時間設定用のスイッチとして応用してもよい。この場合、時計の時間を設定するときには、ボタンを押す強さを基準値と比較し、強いときには1時間単位、弱いときには1分単位で進めるように応用してもよい。また、前記各スイッチ装置は、タイマーの動作時間の設定するスイッチとして応用してもよい。タイマーの動作時間を設定するとき、ボタンを押す強さを基準と比較し、基準値より強いときには1時間単位、弱いときには15分単位で進むように動作させるよう応用してもよい。また、タイマーに応用する場合に、ボタンの押下速度を基準値と比較するように応用してもよい。さらに、目覚まし時計のスイッチとして前記各スイッチを応用してもよい。目覚まし時計を止めるときの押し方をコンピュータに学習させ、基準値を設定する。スイッチを押下したとき、基準値と比較し、その差が大きいときは再動作させるように応用

してもよい。

【0095】前記各スイッチ装置は、テレビジョン受像機のチャネル用スイッチとして応用してもよい。テレビジョン受像機のチャネル用スイッチを押下したときる強さをチャネル用CPUに学習させ基準値を記憶し、基準値との比較によりチャネルの開閉を変化させるように応用してもよい。

【0096】また、前記各スイッチ装置は、ポットの湯量の調節用操作装置に応用してもよい。前記スイッチをポットのCPUに接続させておき、かつポットの湯を前記CPUの制御下に出せるようにする。そして、前記スイッチ装置の押下量、押下速度に応じて湯量を所望のものにするように応用してもよい。

【0097】また、前記各スイッチ装置は、水道の蛇口の開閉をできる装置に応用してもよい。これは、水道の蛇口の開閉をCPUの制御下に行えるようにし、前記スイッチ装置を前記CPUに接続し、前記スイッチ装置の押下量、押下速度等に応じて推量を可変できるようする応用としてもよい。

【0098】加えて、前記各スイッチ装置は、照明装置の調光器に応用してもよい。調光器にはCPUを設け、前記スイッチ装置をCPUに接続し、前記スイッチ装置の操作をCPUに学習させて基準値を得る。そして、前記スイッチ装置が操作されたときに、CPUが前記基準値と比較して照明装置の明るさを調整するようにしてもよい。

【0099】

【発明の効果】以上説明したように本発明では、スイッチの操作量と操作時間とに応じて電気信号が得られるので、情報処理装置では特別な処理をすることなく操作が簡単になり、かつ複雑な処理を行なうことができる。特に、本発明のスイッチ装置をゲーム機に応用した場合、操作量として操作速度、操作量が得られるため、画面に表示されたキャラクターの動作の制御を複雑で詳細な動作態様をさせることができる効果がある。

【0100】また、前記発明によれば、スイッチが導電性ゴムからなる可動接点が、二つの導体を絶縁して円板状に配置した固定接点に接触してゆくとき、導電性ゴムが変形して二つの導体間の抵抗値が変化し、これを電圧値に変換してスイッチの操作量と、信号出力手段で操作速度等の情報とをもつ電気信号にしているので、これを情報処理装置に与えることにより複雑な制御をさせることができる。

【0101】また、本発明によれば、可動磁石が固定コイルに接近するときに右ネジの法則により前記固定コイルに電圧が発生し、信号出力手段においてスイッチの操作量、操作速度等の情報をもつ電気信号にしているので、これを情報処理装置に与えることにより複雑な制御をさせることができる。

【0102】さらに、本発明によれば、ボタンの操作で固定電極と可動電極との間の距離が変化して静電容量が変化し、これを電圧に変化させてスイッチの操作量の電気信号とし、信号出力手段で操作速度等の情報をもつ電気信号にしているので、これを情報処理装置に与えることにより複雑な制御をさせることができる。

【0103】また、本発明によれば、台形状の導電性ゴムからなる可動接点を、前記可動接点に対向する位置に一定間隔で複数の電極を配置してなる固定接点に接触するときに、導電性ゴムが変形して各電極に接触し、各電極に対する前記導電性ゴムの接触面積が変化して複数の電極の接触関係が直接デジタル信号として出力でき、かつ信号出力手段により操作時間に関する情報が得られるため、これを情報処理装置に与えることにより複雑な制御をさせることができ、かつ直接デジタル信号が得られることによりアナログデジタル変換器が不要になる。

【0104】加えて、本発明によれば、半球状の導電性ゴムからなる可動接点が、中心電極に対して一定間隔で複数の電極を円環状に配置してなる固定接点に接触し、導電性ゴムが変形して中心電極から順次外側の電極に向かって接触してゆくことになるため、これを情報処理装置に与えることにより複雑な制御をさせることができ、かつ直接デジタル信号が得られることによりアナログデジタル変換器が不要になる。

【0105】また、前記発明では、前記スイッチをゲーム機に応用したときに、ボタンの押圧力の大小、操作時間等の情報に基づいてキャラクターの動作を制御できるので、キャラクターの移動距離、移動速度、例えば衝突量等が多様に表現させることができる。

【図面の簡単な説明】

【図1】本発明のスイッチ装置の第1の実施例を示す構成図である。

【図2】同第1の実施例の信号出力手段を示す回路図である。

【図3】同第1の実施例で得られ操作信号の例を示す特性図である。

【図4】同第1の実施例の動作を説明するための図である。

【図5】同第2の実施例を示す構成図である。

【図6】同第3の実施例を示す構成図である。

【図7】同第4の実施例を示す構成図である。

【図8】同第4の実施例で使用する信号出力手段の構成を示す回路図である。

【図9】同第4の実施例の信号出力手段の動作を説明するためのタイミングチャートである。

【図10】同第5の実施例を示す構成図である。

【図11】同第6の実施例を示す構成図である。

【符号の説明】

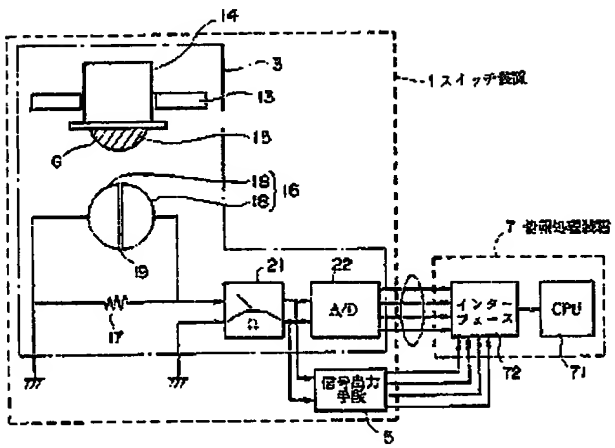
1　スイッチ装置

3，3a，3b，3c，3d　スイッチ

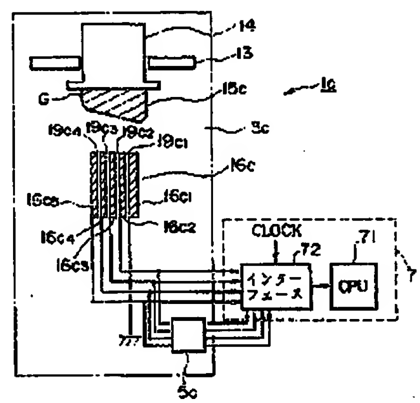
5，5a，5b，5c，5d　信号出力手段

7 情報処理装置
9 情報処理装置
71 CPU
72 インターフェース
91 CPU
92 インターフェース
13 カバー
14 ボタン
15、15c、15d 可動接点
15a 可動磁石 *10
*15b 可動電極
16、16c、16d 固定接点
16a 固定コイル
16b 固定電極
16c1、16c2、16c3、16c4、16c5 電極
16d1、16d2、16d3、16d4、16d5 電極
19 間隙
19c1、19c2、19c3、19c4 間隔
19d1、19d2、19d3、19d4 間隔

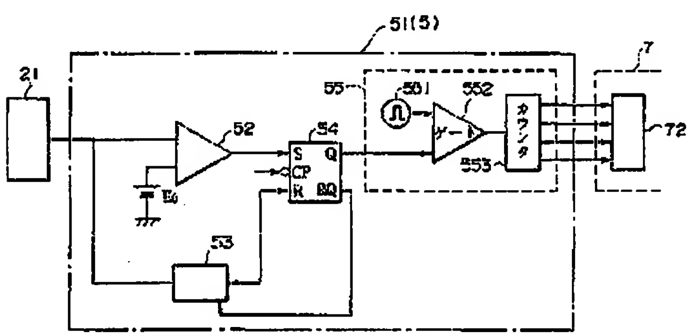
【図1】



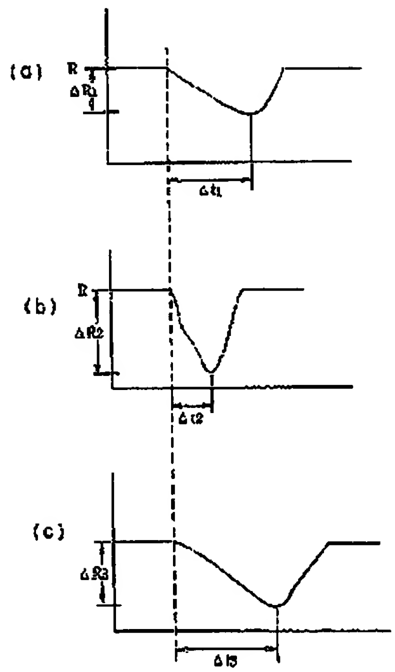
【図7】



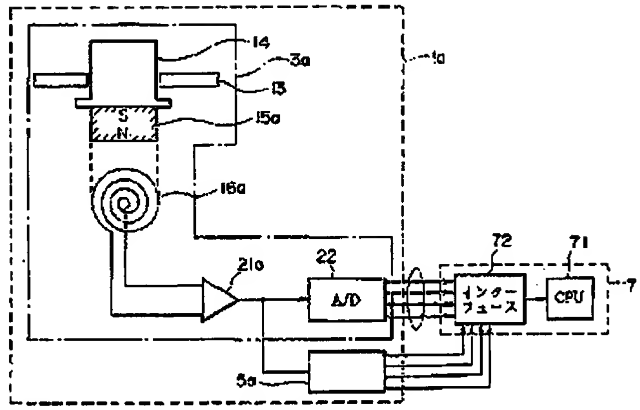
【図2】



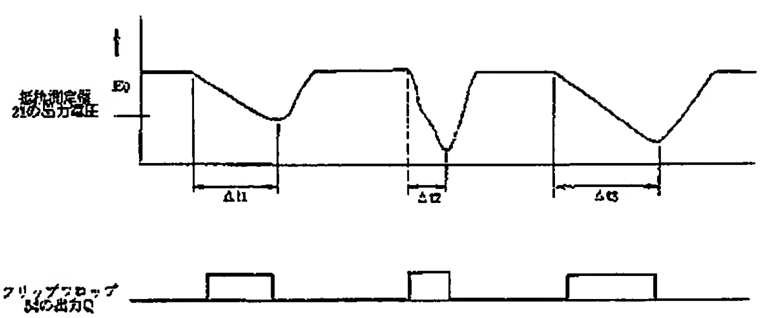
【図3】


(a)
R
ΔR1
Δt1
(b)
R
ΔR2
Δt2
(c)
ΔR3
Δt3

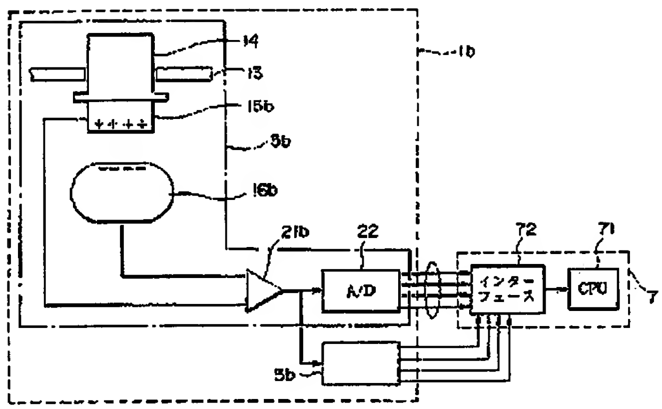
【図5】


14
3a
13
S
N
15a
16a
1a
21a
22
A/D
72
71
インターフェース
CPU
7
5a

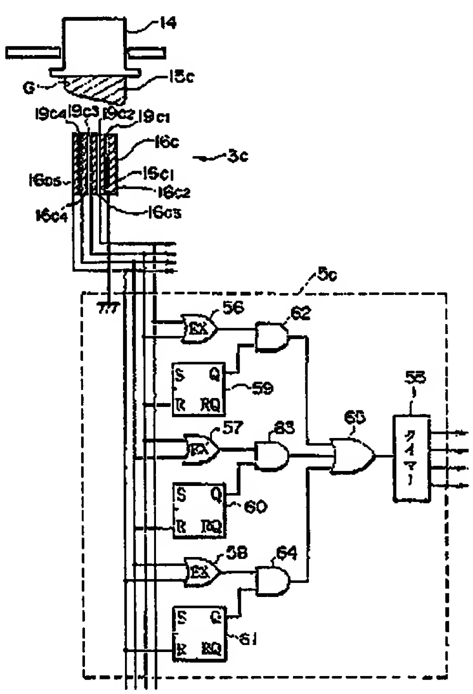
【図4】


E0
抵抗測定器21の出力電圧
Δt1
Δt2
Δt3
フリップフロップ54の出力Q

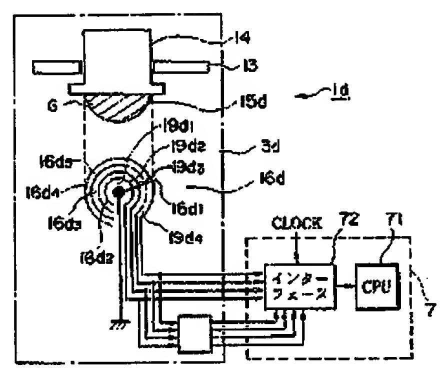
【図6】


14
13
15b
5b
16b
21b
22
A/D
72
71
インターフェース
CPU
7
1b
5b

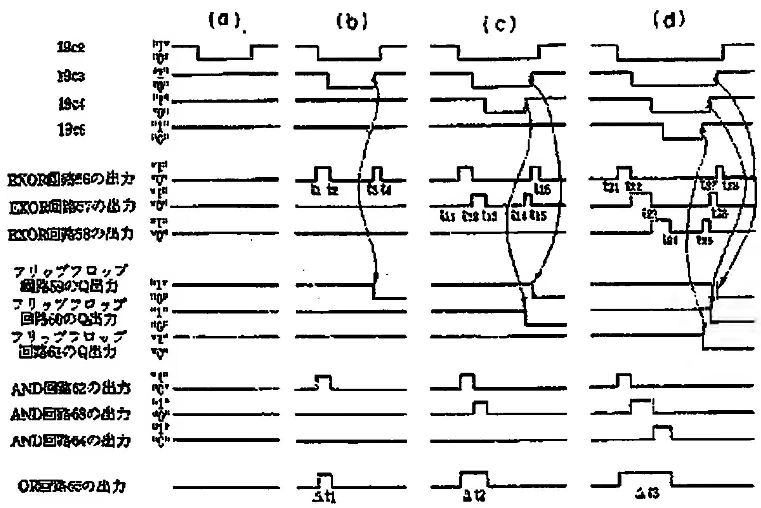
【図8】


14
15c
G
19c4
19c3
19c2
19c1
16c
3c
16c5
16c1
16c2
16c4
16c3
5c
56
62
59
57
63
65
55
タイマ
60
58
64
61

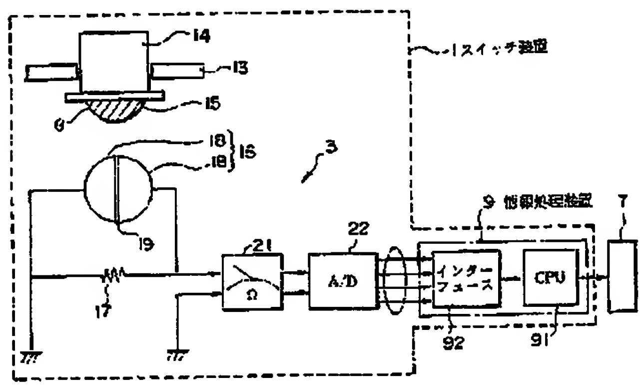
【図10】


14
13
15d
1d
G
19d1
19d2
3d
16d5
19d3
16d
16d4
16d1
16d3
19d4
16d2
CLOCK
72
71
インターフェース
CPU
7

【図9】


(a)
(b)
(c)
(d)
19c2
19c3
19c4
19c6
EXOR回路56の出力
EXOR回路57の出力
EXOR回路58の出力
フリップフロップ回路59のQ出力
フリップフロップ回路60のQ出力
フリップフロップ回路61のQ出力
AND回路62の出力
AND回路63の出力
AND回路64の出力
OR回路65の出力
Δt1
Δt2
Δt3

【図11】


14
13
15
6
18
18
16
3
19
17
21
22
A/D
インターフェース
CPU
9 情報処理装置
7
92
91
1 スイッチ装置

【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第６部門第３区分
【発行日】平成１３年２月１６日（２００１．２．１６）

【公開番号】特開平７－３０２１５９
【公開日】平成７年１１月１４日（１９９５．１１．１４）
【年通号数】公開特許公報７－３０２２
【出願番号】特願平６－１１４３９４
【国際特許分類第７版】
G06F 3/033 310
H01H 13/20
13/50
【ＦＩ】
G06F 3/033 310 Z
H01H 13/20
13/50

【手続補正書】
【提出日】平成１２年３月３０日（２０００．３．３０）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】発明の名称
【補正方法】変更
【補正内容】
【発明の名称】　スイッチ装置及びコンピュータシステム
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】　操作された際に当該操作量に関する信号を出力できるスイッチと、このスイッチの操作量に関する信号から操作時間に関する電気信号を出力する信号出力手段と、を備えるスイッチ装置。
【請求項２】　操作者の操作に応答して可動する可動部と、可動部と連携して作動し操作者の操作に応じたアナログ電気信号を与える固定部とを有するスイッチ装置と、前記アナログ電気信号の時間的変化量を検出する手段と、前記アナログ電気信号の時間的変化量を利用して作動する情報処理手段と、を備えてなるコンピュータシステム。
【請求項３】　前記アナログ電気信号の時間的変化量をデジタル信号に変換することにより操作者の操作量の時間的変化をあらわす信号を出力する操作時間検出回路をさらに備えてなる請求項２記載のコンピュータシステム。
【請求項４】　前記操作時間検出回路は、前記アナログ電気信号が所定値以上となったことを検出するコンパレータと、前記アナログ電気信号が最大値となったことを検出する最大値検出回路と、前記コンパレータの出力信号でセットされ前記最大値検出回路のリセットされるフリップフロップ回路と、前記フリップフロップ回路の出力で起動停止をするタイマーとをさらに備えてなる請求項２または３記載のコンピュータシステム。
【請求項５】　請求項２乃至４の何れかに記載のコンピュータシステムに使用するスイッチ装置であって、前記可動部は固定部に対向して配置された導電性ゴムからなる可動電極を有し、操作者の操作に応答して前記導電性ゴムからなる可動電極が固定部に接触し、接触面積の変化に応じて前記固定部で与えられる電気抵抗値がアナログ的に変化するように構成されてなるスイッチ装置。
【請求項６】　前記固定部は、前記可動電極に対向する位置に導体を間隙を持たせて円形状に配置した構成を有しており、前記導体の固定接点からの抵抗値を計測する抵抗測定器と、前記抵抗測定器からのアナログ量をデジタル信号に変換するＡ／Ｄ変換器とを備える請求項５記載のスイッチ装置。
【請求項７】　請求項２乃至４の何れかに記載のコンピュータシステムに使用するスイッチ装置であって、前記可動部は固定部に対向して配置された可動磁石を有し、前記固定部は前記可動磁石に対向する位置に配置したコイル状の導線からなる固定コイルを有し、操作者の操作に応答して前記可動部が前記固定コイルに近接移動するときに前記固定コイルで発生する電圧の変化をアナログ電気信号として検出するように構成されてなるスイッチ装置。
【請求項８】　前記固定コイルで発生する電圧を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するＡ／Ｄ変換器とを備える請求項７

記載のスイッチ装置。
【請求項9】 請求項2乃至4の何れかに記載のコンピュータシステムに使用する記スイッチ装置であって、前記可動部は固定部に対向して配置された可動電極と、前記可動電極に対向する位置に配置された固定電極と、前記両電極に電荷を与える手段とを有し、操作者の操作に応答して前記可動電極が前記固定電極に近接移動するときに前記両電極の静電容量の変化に応じた電圧の変化をアナログ電気信号として検出するように構成されてなるスイッチ装置。
【請求項10】 前記両電極の静電容量の変化に応じて得られる電圧の変化を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するA／D変換器とを備える請求項9記載のスイッチ装置。
【請求項11】 前記可動部は台形状の導電性ゴムからなる可動電極と、前記可動電極に対向する位置に一定間隔で複数の導体を配置してなる固定電極とを備え、前記複数の導体のそれぞれに接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるように構成されてなる請求項5または6記載のスイッチ装置。
【請求項12】 前記可動部は半球状の導電性ゴムからなる可動電極と、前記可動電極に対向する位置であって、中心位置に中心電極を設け、その中心電極に対して一定間隔で複数の導体を円環状に配置してなる固定電極とを備え、前記中心電極及び円環状に配置された導体に接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるように構成されてなる請求項5または6記載のスイッチ装置。
【請求項13】 操作量に関するアナログ信号の時間的変化量を検出し、これをデジタル信号に変換することにより操作者の操作量の時間的変化をあらわす信号を出力する操作時間検出回路を備えてなる請求項5乃至12の何れかに記載のスイッチ装置。
【請求項14】 前記操作時間検出回路は、前記スイッチからの操作量に関するアナログ信号が所定値以上となったことを検出するコンパレータと、前記アナログ信号が最大値となったことを検出する最大値検出回路と、前記コンパレータの出力信号でセットされ前記最大値検出回路のリセットされるフリップフロップ回路と、前記フリップフロップ回路の出力で起動停止をするタイマーとを備えてなる請求項13記載のスイッチ装置。
【手続補正3】
【補正対象書類名】明細書
【補正対象項目名】0006
【補正方法】変更
【補正内容】
【0006】そこで、この発明は、このような問題点を解決するために、さらに多くの情報をコマンドの選択することなしに与えることができるスイッチ装置及びコンピュータシステムを提供することを目的としている。
【手続補正4】
【補正対象書類名】明細書
【補正対象項目名】0008
【補正方法】変更
【補正内容】
【0008】本発明に係わるコンピュータシステムは、操作者の操作に応答して可動する可動部と、可動部と連携して作動し操作者の操作に応じたアナログ電気信号を与える固定部とを有するスイッチ装置と、前記アナログ電気信号の時間的変化量を検出する手段と、前記アナログ電気信号の時間的変化量を利用して作動する情報処理手段と、を備えてなる。また、上記の構成において、アナログ電気信号の時間的変化量をデジタル信号に変換することにより操作者の操作量の時間的変化をあらわす信号を出力する操作時間検出回路をさらに備えてもよい。好ましくは、前記操作時間検出回路は、前記アナログ電気信号が所定値以上となったことを検出するコンパレータと、前記アナログ電気信号が最大値となったことを検出する最大値検出回路と、前記コンパレータの出力信号でセットされ前記最大値検出回路のリセットされるフリップフロップ回路と、前記フリップフロップ回路の出力で起動停止をするタイマーとをさらに備えている。
【手続補正5】
【補正対象書類名】明細書
【補正対象項目名】0009
【補正方法】変更
【補正内容】
【0009】本発明のスイッチ装置は、上記のコンピュータシステムに使用するスイッチ装置であって、前記可動部は固定部に対向して配置された導電性ゴムからなる可動電極を有し、操作者の操作に応答して前記導電性ゴムからなる可動電極が固定部に接触し、接触面積の変化に応じて前記固定部で与えられる電気抵抗値がアナログ的に変化するように構成されてなる。好ましくは、前記固定部は、前記可動電極に対向する位置に導体を間隙を持たせて円形状に配置した構成を有しており、前記導体の固定接点からの抵抗値を計測する抵抗測定器と、前記抵抗測定器からのアナログ量をデジタル信号に変換するA／D変換器とを備える。
【手続補正6】
【補正対象書類名】明細書
【補正対象項目名】0010
【補正方法】変更
【補正内容】
【0010】本発明のスイッチ装置は、上記のコンピュータシステムに使用するスイッチ装置であって、前記可動部は固定部に対向して配置された可動磁石を有し、前記固定部は前記可動磁石に対向する位置に配置したコイル状の導線からなる固定コイルを有し、操作者の操作に

応答して前記可動部が前記固定コイルに近接移動するときに前記固定コイルで発生する電圧の変化をアナログ電気信号として検出するように構成されてなる。好ましくは、前記固定コイルで発生する電圧を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するA／D変換器とを備える。

【手続補正７】
【補正対象書類名】明細書
【補正対象項目名】００１１
【補正方法】変更
【補正内容】
【００１１】本発明のスイッチ装置は、上記のコンピュータシステムに使用する記スイッチ装置であって、前記可動部は固定部に対向して配置された可動電極と、前記可動電極に対向する位置に配置された固定電極と、前記両電極に電荷を与える手段とを有し、操作者の操作に応答して前記可動電極が前記固定電極に近接移動するときに前記両電極の静電容量の変化に応じた電圧の変化をアナログ電気信号として検出するように構成されてなる。

【手続補正８】
【補正対象書類名】明細書
【補正対象項目名】００１２
【補正方法】変更
【補正内容】
【００１２】好ましくは、本発明のスイッチ装置は上記の構成において、前記両電極の静電容量の変化に応じて得られる電圧の変化を増幅する演算増幅器と、前記演算増幅器からのアナログ量をデジタル信号に変換するA／D変換器とを備える。

【手続補正９】
【補正対象書類名】明細書
【補正対象項目名】００１３
【補正方法】変更
【補正内容】
【００１３】好ましくは、本発明のスイッチ装置は上記の構成において、前記可動部は台形状の導電性ゴムからなる可動電極と、前記可動電極に対向する位置に一定間隔で複数の導体を配置してなる固定電極とを備え、前記複数の導体のそれぞれに接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるように構成されてなる。

【手続補正１０】
【補正対象書類名】明細書
【補正対象項目名】００１４
【補正方法】変更
【補正内容】
【００１４】好ましくは、本発明のスイッチ装置は上記の構成において、前記可動部は半球状の導電性ゴムからなる可動電極と、前記可動電極に対向する位置であって、中心位置に中心電極を設け、その中心電極に対して一定間隔で複数の導体を円環状に配置してなる固定電極とを備え、前記中心電極及び円環状に配置された導体に接触する前記導電性ゴムの接触面積に応じて操作量に関するデジタル量として出力できるように構成されてなる。

【手続補正１１】
【補正対象書類名】明細書
【補正対象項目名】００１５
【補正方法】変更
【補正内容】
【００１５】好ましくは、本発明のスイッチ装置は上記の構成において、操作量に関するアナログ信号の時間的変化量を検出し、これをデジタル信号に変換することにより操作者の操作量の時間的変化をあらわす信号を出力する操作時間検出回路を備えてなる。

【手続補正１２】
【補正対象書類名】明細書
【補正対象項目名】００１６
【補正方法】変更
【補正内容】
【００１６】好ましくは、本発明のスイッチ装置は上記の構成において、前記操作時間検出回路は、前記スイッチからの操作量に関するアナログ信号が所定値以上となったことを検出するコンパレータと、前記アナログ信号が最大値となったことを検出する最大値検出回路と、前記コンパレータの出力信号でセットされ前記最大値検出回路のリセットされるフリップフロップ回路と、前記フリップフロップ回路の出力で起動停止をするタイマーとを備えてなる。

【手続補正１３】
【補正対象書類名】明細書
【補正対象項目名】００２８
【補正方法】変更
【補正内容】
【００２８】図１に示すスイッチ装置１は、スイッチの操作量と操作時間に応じた電気信号を出力できるように構成されている。このスイッチ装置１は、情報処理装置７に電気的に接続されており、前記スイッチの操作量と操作時間に応じた電気信号を情報処理装置７に供給できるようになっている。

【手続補正１４】
【補正対象書類名】明細書
【補正対象項目名】００３５
【補正方法】変更
【補正内容】
【００３５】前記情報処理装置７は、この実施例では、CPU７１、及びインターフェース７２のみを図示しているが、ROM、RAM、I／O装置、表示装置、外部記憶装置、その他処理に必要な各種要素を備えている。

【手続補正１５】

【補正対象書類名】明細書
【補正対象項目名】００３６
【補正方法】変更
【補正内容】
【００３６】図２は、信号出力手段５の具体的回路構成例を示すブロック図である。図２において、信号出力手段５は操作時間検出回路５１からなり、次のように構成されている。操作時間検出回路５１は、コンパレータ５２、最大値検出回路５３、フリップフロップ回路５４、タイマー５５とを備えている。前記抵抗測定器２１の出力端子は、コンパレータ５２及び最大値検出回路５３の各入力端子に接続されており、抵抗電圧変換回路２１からのアナログ操作量信号が供給されるようになっている。コンパレータ５２の出力端子は、フリップフロップ回路５４のセット端子Sに接続されている。最大値検出回路５３の出力端子は、フリップフロップ回路５４のリセット端子Rに接続されている。また、フリップフロップ回路５４のクロック端子ＣＰには動作用クロックが入力されている。フリップフロップ回路５４の非反転出力端子Qはタイマー５５の起動停止制御端子に接続されており、出力端子Qが"１"のときのみにタイマー５５が起動するようにしてある。また、フリップフロップ回路５４の反転出力端子RQは最大値検出回路５３のリセット端子に接続されている。
【手続補正１６】
【補正対象書類名】明細書
【補正対象項目名】００５１
【補正方法】変更
【補正内容】
【００５１】このようなスイッチ装置１ａによれば、ボタン１４の押下により、可動磁石１５ａが固定コイル１６ａに近づき、その速度に応じて右ネジの法則により固定コイル１６ａに電圧が発生する。この電圧は、ボタン１４の押し下げる速度に比例して増減するので、その電圧の変化を演算増幅器２１ａで増幅し、A／D変換機２２でデジタル信号にして情報処理装置７のインターフェース７２を介してＣＰＵ７１に与える。
【手続補正１７】
【補正対象書類名】明細書
【補正対象項目名】００６６
【補正方法】変更
【補正内容】
【００６６】このスイッチ装置１ｃは、操作されたときに、操作量に応じて電気信号を出力するスイッチ３ｃと、前記スイッチ３ｃからの操作量に応じた電気信号から操作時間に関する信号を得る信号出力手段５ｃとからなる。
【手続補正１８】
【補正対象書類名】明細書
【補正対象項目名】００６７
【補正方法】変更
【補正内容】
【００６７】ここで、前記スイッチ３ｃは、次のように構成されている。すなわち、スイッチ装置１ｃは、カバー１３、ボタン１４、可動接点１５ｃ、固定接点１６ｃを備えている。カバー１３は、スイッチ装置１ｃの本体を構成する外側の器枠であり、このカバー１３にボタン１４が図示上下可能に固定されている点で第１の実施例と同一である。このボタン１４は、図示下端部に図示左側が図示右側より低い台形状をした導電性ゴムGで構成した可動接点１５ｃが固定されている点で第１の実施例と異なるが、図示しないコイルばね等で図示上側に常時付勢されている点では第１の実施例と同一である。この可動設定１５ｃに対向した位置には、固定接点１６ｃが配設されている。この固定接点１６ｃは、複数の電極１６c1、１６c2、１６c3、１６c4、１６c5が一定間隔１９c1、１９c2、１９c3、１９c4を持たせて配設されている。電極１６c1は接地されており、４つの電極１６c2、１６c3、１６c4、１６c5は情報処理装置７のインターフェース７２に接続されている。これにより、４ビットのデジタル信号として出力される。また、インターフェース７２には、クロックＣＬＯＣＫが入力されている。
【手続補正１９】
【補正対象書類名】明細書
【補正対象項目名】００７０
【補正方法】変更
【補正内容】
【００７０】次に、前記第４実施例の動作を図７乃至図９を参照して説明する。図９は、前記第４の実施例の動作を説明するためのタイミングチャートであり、横軸に時間を、縦軸に各部の信号を示している。
【手続補正２０】
【補正対象書類名】明細書
【補正対象項目名】００７１
【補正方法】変更
【補正内容】
【００７１】このように構成されたスイッチ装置１ｃによれば、ボタン１４を図示しないコイルばねの付勢力に抗して押下すると、可動接点１５ｃの導電性ゴムGが固定接点１６ｃの電極１６c1に接触する。さらに押下されると電極１６c1、１６c2が可動接点１５ｃの導電性ゴムGが変形することにより接続される。さらに、押下すると、可動接点１５ｃの導電性ゴムGが固定接点１６ｃの電極１６c1、１６c2、１６c3に接触しながら変形してゆく。このようにして可動接点１５ｃの導電性ゴムGの接触面積が広がり、それに伴って電極１６c1、１６c2、１６c3、１６c4、１６c5が徐々に接地されてゆく。このような導電性ゴムGと電極１６c1、１６c2、１６c3、１６c4、１６c5の接続関係がボタン１４の押下力と押下速度で変化する。このような固定接点１６ｃの電極１６c1、

16c2，16c3，16c4，16c5の接続関係は，直接情報処理装置7のインターフェース72に入力されて、CPU71に与えられる。

【手続補正21】

【補正対象書類名】明細書

【補正対象項目名】0082

【補正方法】変更

【補正内容】

【0082】ここで、前記スイッチ3dは、カバー13，ボタン14，可動接点15d、固定接点16dを備えている点で第4の実施例と同様である。前記カバー13にボタン14が図示上下動可能に固定されている点で第1の実施例と同一である。このボタン14は，図示下端部に図示半球状をした導電性ゴムGで構成した可動接点15dが固定されており，かつ図示しないコイルばね等で図示上側に常時付勢されている点で第1の実施例と同一である。この可動設定15dに対向した位置には、固定接点16dが配設されている。この固定接点16dは，中心電極16d1の周囲に対して，複数の電極16c2，16c3，16c4，16c5が一定間隔19d1，19d2，19d3，19d4を持たせて円形状に配設されている。これら電極16d1は接地されており、電極16d2，16d3，16d4，16d5は情報処理装置7のインターフェース32に直接接続されている。また、インターフェース32には，クロックCLOCKが入力されている。

【手続補正22】

【補正対象書類名】明細書

【補正対象項目名】0089

【補正方法】変更

【補正内容】

【0089】CPU91は，スイッチ3から出力されるデジタル信号を取込み、合成抵抗Roの抵抗値の変化を電圧値で記憶し，これらの情報から，抵抗値の変化ΔRと，抵抗値の変化時間Δtと、抵抗値の変化の積分値とを判断する。これは、次のようにして判断する。CPU91は、合成抵抗Roを一定時間間隔で取り込んでいるので，一つ前の取込み時間における抵抗値と現取り込み時間における抵抗値とを比較し、現取込み時間における抵抗値が大きくなったときに、前の取込み時間の抵抗値が最小値になったと判断する。そして，CPU91は、前記判断から，抵抗値の変化の最初から抵抗値が最小値になったときまでの時間Δtと抵抗値の変化分ΔRとを求めることができる。また，CPU91は、前記各取込み時間における抵抗値の全部を加算することにより合成抵抗Roの変化分の積分値を得ることができる。このようにして求めた合成抵抗Roの変化分ΔRと変化時間Δtと変化の積分値をCPU91は他の情報処理装置7に与えることができる。もちろん、情報処理装置7と情報処理装置9とを兼用するようにしてもよい。

【手続補正23】

【補正対象書類名】明細書

【補正対象項目名】0090

【補正方法】変更

【補正内容】

【0090】上述したような各スイッチ装置の実施例は，次のような分野に応用することができる。

【手続補正24】

【補正対象書類名】明細書

【補正対象項目名】0092

【補正方法】変更

【補正内容】

【0092】また、前記各スイッチ装置は、ユーザー判別キーボードに応用することができる。ユーザーのキータッチの仕方等をパーソナルコンピュータに学習させ、基準値とする。キータッチがあるたびに前記基準値と比較し，その差が大きいときにはユーザー以外であると判断し，パーソナルコンピュータはロック又はリセット等を実行するように応用してもよい。ここで使用するキータッチのデータとしては，キーを押下する速度等とする。

【手続補正25】

【補正対象書類名】明細書

【補正対象項目名】0104

【補正方法】変更

【補正内容】

【0104】加えて、本発明によれば，半球状の導電性ゴムからなる可動接点が，中心電極に対して一定間隔で複数の電極を円環状に配置してなる固定接点に接触し、導電性ゴムが変形して中心電極から順次外側の電極に向かって接触してゆくことになるため，これを情報処理装置に与えることにより複雑な制御をさせることができ、かつ直接デジタル信号が得られることによりアナログデジタル変換器が不要になる。

【手続補正26】

【補正対象書類名】明細書

【補正対象項目名】図面の簡単な説明

【補正方法】変更

【補正内容】

【図面の簡単な説明】

【図1】本発明のスイッチ装置の第1の実施例を示す構成図である。

【図2】同第1の実施例の信号出力手段を示す回路図である。

【図3】同第1の実施例で得られる操作信号の例を示す特性図である。

【図4】同第1の実施例の動作を説明するための図である。

【図5】同第2の実施例を示す構成図である。

【図6】同第3の実施例を示す構成図である。

【図7】同第4の実施例を示す構成図である。

【図8】同第4の実施例で使用する信号出力手段の構成を示す回路図である。
【図9】同第4の実施例の信号出力手段の動作を説明するためのタイミングチャートである。
【図10】同第5の実施例を示す構成図である。
【図11】同第6の実施例を示す構成図である。

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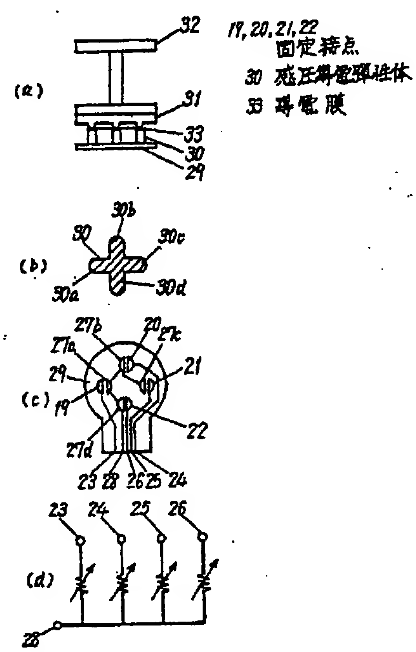
(54)【発明の名称】　感圧スイッチ

(57)【要約】
【目的】　音響機器、映像機器、ゲーム機等の入力操作部に用いられる感圧スイッチにおいて、感度の良い押圧力検出を目的とする。
【構成】　４方向に配置した４個の独立した固定接点１９～２２に対向する共通固定接点２７ａ，２７ｂ，２７ｃ，２７ｄを下部フィルム２９に設け、固定接点１９～２２との接触側に対向した押圧操作面側に、導電膜３３を形成した感圧導電弾性体３０を固定接点１９～２２の上部に配置し、さらに、感圧導電弾性体３０を押圧するための凸部が設けられた押圧板３１と、力の加えられた方向に押圧板３１を押す操作レバー３２を押圧板３１の上に配置して構成することにより、操作レバーの動きに対して、感圧導電弾性体３０の抵抗値変化を感度良くすることができる優れた感圧スイッチが得られる。



【特許請求の範囲】
【請求項１】　少なくとも２つの固定接点と、これら固定接点上に載置され、固定接点との接触側に対向した押圧操作面側に導電材料を塗布し導電膜を形成した感圧導電弾性体とからなる感圧スイッチ。
【請求項２】　中央上部の押し釦部と中央下部の押圧部と外周支持部とを有するドーム状弾性体を、感圧導電弾性体の上部に載置した請求項１記載の感圧スイッチ。
【請求項３】　２つの固定接点上に、感圧導電弾性体を介して、ドーム状弾性体の押圧部を配置した請求項２記載の感圧スイッチ。
【請求項４】　中央の固定接点上に、感圧導電弾性体を介してドーム状弾性体の押圧部を配置し、外周の固定接点上に、感圧導電弾性体を介してドーム状弾性体の外周支持部を配置し、前記ドーム状弾性体の押し釦部が突出する孔を有するカバーにより、前記ドーム状弾性体の前記外周支持部を介して感圧導電弾性体を挟み込んだ請求項２記載の感圧スイッチ。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、固定接点上に、固定接点との接触側に対向した押圧操作面側に導電材料を塗布し導電膜を形成した感圧導電弾性体を配置した感圧スイッチに関するものである。
【０００２】
【従来の技術】近年、音響機器、映像機器、ゲーム機等の入力操作部に用いられる感圧スイッチは、ポインティングデバイスの感度を向上させるよう要望が高まっている。
【０００３】以下に従来の感圧スイッチについて説明する。図６（ａ）～（ｅ）は従来の感圧スイッチの構成を示すものである。同図において１～４は４方向に配置した４個の独立した固定接点であり、５～８は固定接点からの引き出し線であり、９ａ，９ｂ，９ｃ，９ｄは４個の独立した固定接点１～４にそれぞれに対向する共通固定接点であり、１０はその共通固定接点からの引き出し線であり、これらは下部フィルム１１に設けられている。１２は上部フィルムであり、可動接点１４が設けられている。１３は固定接点と可動接点間の厚み方向の圧力によって抵抗値が変化する感圧導電ゴムであり、１５は４方向に配置された感圧導電ゴム１３の位置を押すための凸部が４方向に設けられた押圧板であり、１６は押圧板の上に配置され、力の加えられた方向に押圧板１５を押す操作レバーである。
【０００４】また等価回路に示すように１０の引き出し線と５～８の引き出し線との間の抵抗を測定する事によって個々の接点間の抵抗値変化を測定できる。つまり感圧ゴムの各部の上下間の抵抗値を測定する事によって、どの方向にどのような力で力が加えられたかという「方向」と「力の大きさ」を知る事ができる。
【０００５】
【発明が解決しようとする課題】しかしながら上記の従来の構成では、感圧導電ゴム１３の上に可動接点１４を設けた上部フィルム１２を配置する必要があるため、スイッチを操作する際、押圧板１５の凸部が上部フィルム１２を介して感圧導電ゴム１３を押すことになり、上部フィルム１２の厚みと剛性の影響により感圧導電ゴム１３の感度が鈍くなるという問題点を有していた。
【０００６】本発明は上記従来の問題点を解決するもので、圧力検出感度が優れた感圧スイッチを提供することを目的とする。
【０００７】
【課題を解決するための手段】この目的を達成するために本発明の感圧スイッチは、１つ、または少なくとも２つの固定接点と、これら固定接点上に載置され、前記固定接点との接触側に対向した押圧操作面側に導電材料を塗布した感圧導電弾性体を配設した構成を有している。
【０００８】
【作用】この構成によって、４方向に配置した４対の独立した固定接点と、これらの固定接点からの引き出し線を配線したフィルムと、前記固定接点との接触側に対向した押圧操作面側に導電材料を塗布した感圧導電弾性体を前記固定接点の上部に配置し、これら固定接点の上部に配置された前記感圧導電弾性体を押圧するための凸部が４方向に設けられた押圧板と、前記押圧板の上に配置され力の加えられた方向に前記押圧板を押す操作レバーとで構成することによって、前記操作レバーに加えられた力が前記押圧板の前記凸部を通じて４方向の前記感圧導電弾性体に加えられる事により、前記感圧導電弾性体の抵抗値変化を引き出し線から読み取ることができる。
【０００９】
【実施例】
（実施例１）以下本発明の第１の実施例について、図面を参照しながら説明する。
【００１０】図１（ａ）～（ｄ）において、１９～２２は４方向に配置した４個の独立した固定接点であり、２３～２６は固定接点１９～２２からの引き出し線であり、２７ａ，２７ｂ，２７ｃ，２７ｄは４個の独立した固定接点１９～２２にそれぞれに対向する共通固定接点であり、２８はその共通固定接点からの引き出し線であり、これらは下部フィルム２９に設けられている。また、固定接点１９～２２との接触側に対向した押圧操作面側に導電材料を塗布し導電膜３３を形成した感圧導電ゴムからなる感圧導電弾性体３０の先端部３０ａ，３０ｂ，３０ｃ，３０ｄを４対の独立した固定接点１９～２２の上部に配置している。
【００１１】さらに、４対の独立した固定接点１９～２２の上部に配置された感圧導電弾性体３０を押圧するための凸部が４方向に設けられた押圧板３１と、押圧板３１の上に配置され力の加えられた方向に押圧板３１を押

す操作レバー３２とで構成されている。また等価回路に示すように引き出し線２８と引き出し線２３〜２６との間の抵抗を測定する事によって個々の接点間の抵抗値変化を測定できる。

【００１２】以上のように構成された感圧スイッチについて、図２を用いてその動作を説明する。

【００１３】操作レバー３２を矢印Ａ方向の力で押すと、押圧板の４個所の凸部には、押した位置に対応する矢印Ｂ方向の力が働く。特に感圧導電弾性体３０にはB_1，B_2のように下向きに力が加わるので、感圧導電弾性体の先端部の３０ａ，３０ｂ，３０ｃ，３０ｄの上下間の抵抗値を測定する事によって、どの方向にどのような力で力が加えられたかという「方向」と「力の大きさ」を知る事ができる。つまり図５の等価回路出力特性図に示すような特性に従って抵抗値が減少する。例えば、感圧導電弾性体３０の厚み方向の抵抗値が６ＫΩのときは押し圧は２００ｇであるというように感圧導電弾性体３０の抵抗値を測定する事によって押し圧力を知る事ができる。

【００１４】以上のように本実施例によれば、感圧導電弾性体３０の上面に薄い導電膜３３が印刷等で形成されており、従来の上部フィルムが不要なことから、直接感圧導電弾性体３０を押すことになり、ポインティングデバイスの感度を向上することができる。

【００１５】（実施例２）以下本発明の第２の実施例について図面を参照しながら説明する。

【００１６】図３において、４１ａ，４２ａは対向する一対の固定接点であり、これらは出力端子４１ｂ，４２ｂとそれぞれ導通しておりスイッチケース４３にインサート成形されている。固定接点４１ａ，４２ａの上部には、固定接点４１ａ，４２ａとの接触側に対向した押圧操作面側に導電材料を塗布し導電膜４４ａを形成した感圧導電弾性体４４が配置され、その上部には押し釦部４５ａと押圧部４５ｂと外周支持部４５ｃとを有するドーム状弾性体４５が配置され、カバー４６で保持されると共に覆われている。

【００１７】以上のように構成された感圧スイッチについて、図３を用いてその動作を説明する。

【００１８】ドーム状弾性体４５の押し釦部４５ａが下向きに押圧されることにより、押圧部４５ｂは感圧導電弾性体４４の中心付近に接触し、さらに押圧されることにより感圧導電弾性体４４は、固定接点４１ａ，４２ａと押し釦部４５ａに挟まれる形となり、厚み方向に加圧されることになる。この結果、感圧導電弾性体４４の厚み方向の抵抗値は図６の等価回路出力特性図に示すように圧力と共に徐々に低下し、ついには出力端子４１ｂと４２ｂ間は導通状態となる。すなわち電流の経路としては、４２ｂ〜４２ａ〜４４〜４４ａ〜４４〜４１ａ〜４１ｂとなる。

【００１９】以上のように本実施例によれば、従来のプッシュスイッチにおいて感圧導電弾性体４４の替わりに金属接点が配置されており、ＯＮ／ＯＦＦの状態検出しかできなかったのに対して、押し釦部４５ａを押す圧力に応じて出力抵抗値が変化するため、電圧比較器またはＡ／Ｄコンバータに接続することにより、多段階スイッチとして使用することができる。

【００２０】（実施例３）以下本発明の第３の実施例について図面を参照しながら説明する。

【００２１】図４において、５１ａ，５２ａは一対の固定接点であり、これらは出力端子５１ｂ，５２ｂとそれぞれ導通しておりスイッチケース５３にインサート成形されている。固定接点５１ａ，５２ａの上部には、固定接点５１ａ，５２ａとの接触側に対向した押圧操作面側に導電材料を塗布し導電膜５４ａを形成した感圧導電弾性体５４が配置され、その上部には押し釦部５５ａと押圧部５５ｂと外周支持部５５ｃとを有するドーム状弾性体５５が配置され、カバー５６で挟み込まれている。このため外周支持部５５ｃは、厚み方向に大きな荷重を受けており、厚み方向の抵抗値は小さく導通状態となっている。

【００２２】以上のように構成された感圧スイッチについて、図４を用いてその動作を説明する。ドーム状弾性体５５の押し釦部５５ａが下向きに押圧されることにより、押圧部５５ｂは感圧導電弾性体５４の中心付近に接触し、さらに押圧されることにより感圧導電弾性体５４は、固定接点５１ａと押圧部５５ｂに挟まれる形となり、厚み方向に加圧されることになる。この結果、感圧導電弾性体５４の厚み方向の抵抗値は図６の等価回路出力特性図に示すように加圧と共に徐々に低下し、ついには出力端子５１ｂと５２ｂ間は導通状態となる。すなわち電流が流れる経路としては、５１ｂ〜５１ａ〜５４〜５４ａ〜５４〜５２ａ〜５２ｂとなる。

【００２３】以上のように本実施例によれば、固定接点５２ａ上部の感圧導電弾性体５４がドーム状弾性体５５の外周支持部５５ｃを介してカバー５６に挟み込まれているため、この部分での感圧導電弾性体５４の抵抗値は充分低下しており、固定接点５１ａ上部１箇所だけでの感圧導電弾性体５４の抵抗値変化だけが、出力端子５１ｂと５２ｂ間から出力されることになり、より安定した押圧力の検出が可能となり、電圧比較器またはＡ／Ｄコンバータに接続することにより、多段階スイッチとして使用することができる。

【００２４】なお、感圧導電弾性体として、ゴム、樹脂、絶縁フィルムの上に感圧導電材料を塗布し導電膜を形成したものが用いられる。

【００２５】

【発明の効果】以上のように本発明は、固定接点との接触側に対向した押圧操作面側に導電材料を塗布し導電膜を形成した感圧導電弾性体を用いたので、押圧部により直接前記感圧導電弾性体を加圧することとなり、従来の

上部フィルムを用いた構成に比べてより感度の良い圧力検出が可能である。

【0026】また可動接点に、導電材料を塗布し導電膜を形成した前記感圧導電弾性体を用いてプッシュスイッチを構成することにより、従来の構成では不可能であった多段階スイッチとして使用することも可能となった。さらに従来のプッシュスイッチの可動接点の替わりに前記感圧導電弾性体を用いる構成であるため、従来のプッシュスイッチの自動組立機を用いて組み立てることができ、大幅な工数削減を可能とすることができる優れた感圧スイッチを実現できるものである。

【図面の簡単な説明】

【図1】（a）本発明の第1の実施例における感圧スイッチの側面図

（b）同第1の実施例における感圧導電弾性体の平面図

（c）同第1の実施例における下部フィルムの平面図

（d）同第1の実施例における感圧スイッチの等価回路図

【図2】同第1の実施例における感圧スイッチの動作説明のための斜視図

【図3】本発明の第2の実施例における感圧スイッチの断面図

【図4】本発明の第3の実施例における感圧スイッチの断面図

【図5】本発明の第1，第2，第3の実施例における感圧スイッチの等価回路出力特性図

【図6】（a）従来の感圧スイッチの側面図

（b）同上部フィルムの平面図

（c）同要部である感圧導電ゴムの底面図

（d）同下部フィルムの平面図

（e）同等価回路図

【符号の説明】

19　20，21，22，41a，42a，51a，52a　固定接点

30，44，54　感圧導電弾性体

33，44a，54a　導電膜

45，55　ドーム状弾性体

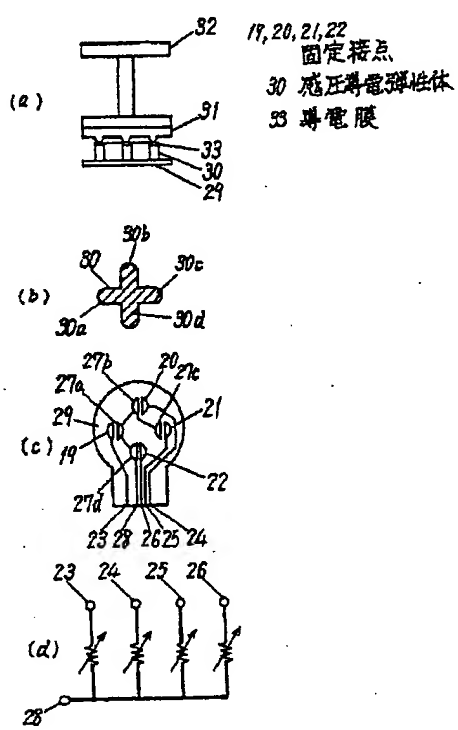
45a，55a　押し釦部

45b，55b　押圧部

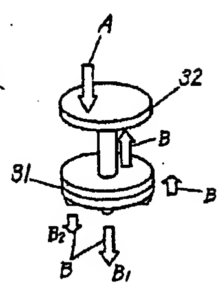
45c，55c　外周支持部

46，56　カバー

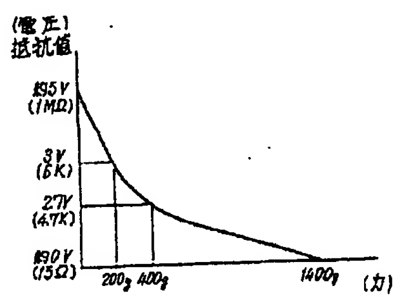
【図1】



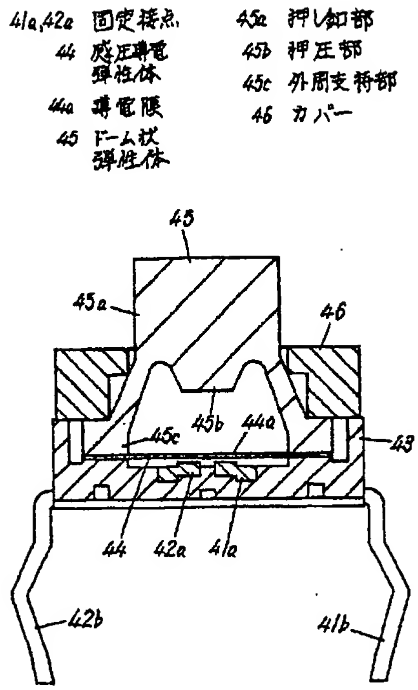
【図2】



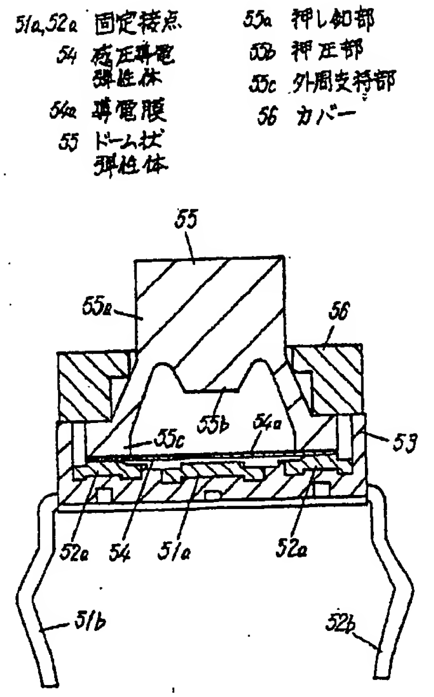
【図5】



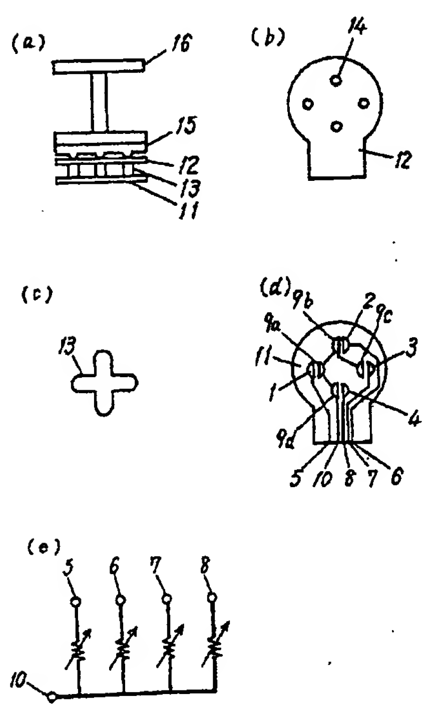
【図3】



【図4】



【図6】



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(54) [Title of the invention] Pressure-sensitive switch

(57) [Abstract]

[Objective]

To provide pressure force detection with good sensitivity in a pressure-sensitive switch used in the input operation of a sound device, video device, or gaming device or the like.

[Structure]

Common secure connection points 27a, 27b, 27c, and 27d are attached to a lower film 29 facing four independent secure connection points 19-22 arranged in four directions, and a pressure-sensitive electroconductive elastic body 30 having an electroconductive coating 33 on the pressure operating surface side opposite to the side that is in contact with the secure connection points 19-22 is placed on the secure connection points 19-22. Furthermore, a pressure plate 31 having protrusions for pressing the pressure-sensitive electroconductive elastic body 30 and an operating lever 32 placed on the pressure plate 31 for pressing it in the direction of applied force are provided so that a superior pressure-sensitive switch is obtained capable of changing the resistance value of the pressure-sensitive electroconductive elastic body 30.

[Claims]

[Claim 1]

A pressure-sensitive switch comprising at least two secure contact points and a pressure-sensitive electroconductive elastic body that is placed on said secure contact points and coated with an electroconductive material to form an electroconductive coating on the pressure operating surface side opposite to the side that is in contact with said secure connection points.

[Claim 2]

The pressure-sensitive switch according to Claim 1, wherein a dome-shaped elastic body having a press button at the top center, a pressuring part at the bottom center, and a peripheral supporting part is placed on said pressure-sensitive electroconductive elastic body.

[Claim 3]

The pressure-sensitive switch according to Claim 2, wherein said pressing part of said dome-shaped elastic body is placed on two secure contact points via said the pressure-sensitive electroconductive elastic body.

[Claim 4]

The pressure-sensitive switch according to Claim 2, wherein said pressing part of said dome-shaped elastic body is placed on the center secure contact point via said pressure-sensitive electroconductive elastic body, said peripheral supporting part of said dome-shaped elastic body is placed on the peripheral secure contact points via said pressure-sensitive electroconductive elastic body, and said pressure-sensitive electroconductive elastic body is clamped by a cover having an opening through which said press button of said dome-shaped elastic body protrudes via said peripheral supporting part of said dome-shaped elastic body.

[Detailed explanation of the invention]

[0001]

[Scope of the invention]

The present invention relates to a pressure-sensitive switch in which a pressure-sensitive electroconductive elastic body is placed on secure contact points and coated with an electroconductive material to form an electroconductive coating on the pressure operating surface side opposite to the side that is in contact with the secure contact points.

[0002]

[Prior art technology]

In recent years, there has been heightened desire for pressure-sensitive switch used in the input operation of a sound device, video device, or gaming device or the like to have improved pointing device sensitivity.

[0003]

An explanation is provided hereafter concerning conventional pressure-sensitive switches. Figure 6 (a)-(e) shows the structure of conventional pressure-sensitive switches. In the drawing, 1-4 indicate four independent secure contact points arranged in four directions; 5-8 represent leads drawn from the secure contact points; 9a, 9b, 9c, and 9d represent common secure contact points respectively facing the four independent contact points 1-4, no. 10 represents a lead drawn from the common secure contact points, and which are attached to a lower film 11. No. 12 represents an upper film, to which movable contact points 14 are attached. No. 13 is a pressure-sensitive electroconductive rubber having variable resistance in accordance with the pressure between the secure and movable contact points in the thickness direction. No. 15 is a pressure plate having protrusions in four directions for pressing the points in four directions on the pressure-sensitive electroconductive rubber 13, and no.16 represents an operating lever that is arranged on the pressure plate and pushes it in the direction of applied force.

[0004]

Changes in resistance between individual contact points are measured by measuring respective resistances between the lead line 10 and the lead lines 5-8. In other words, measurements of resistances between the top and bottom at each position of the pressure-sensitive rubber provide information on in which direction and of what magnitude the force is applied, namely the "direction" and "magnitude" of the force.

[0005]

[Problems overcome by the invention]

However, the above structure requires the upper film 12 having the movable contact points 14 on the pressure-sensitive electroconductive rubber 13. Therefore, when the switch is operated, the protrusions of the pressure plate 15 push the pressure-sensitive electroconductive rubber 13 via the upper film 12. This raises a problem that the pressure-sensitive electroconductive rubber 13 is less sensitive under influence of the thickness and rigidity of the upper film 12.

[0006]

The present invention resolves the prior art problem described above and the purpose of the present invention is to provide a pressure-sensitive switch having an excellent pressure detection sensitivity.

[0007]

[Problem resolution means]

In order to achieve the above purpose, the pressure-sensitive switch of the present invention comprises one or at least two secure contact points and a pressure-sensitive electroconductive elastic body that is placed on the secure contact points and coated with an electroconductive material to form an electroconductive coating on the pressure operating surface side opposite to the side that is in contact with the secure connection points.

[0008]

[Efficacy]

With the above structure comprising four pairs of independent secure contact points arranged in four directions, a film on which leads drawn from these secure contact points are wired, a pressure-sensitive electroconductive elastic body that is placed on the secure contact points and coated with an electroconductive material on the pressure operating surface side opposite to the side that is in contact with the secure contact points, a pressure plate having protrusions in four directions for pressing the pressure-sensitive electroconductive elastic body on the secure contact points, and an operating lever that is placed on the pressure plate 31 for pressing the pressure plate in the direction of applied force, the force applied to the operating lever is further applied to the pressure-sensitive electroconductive elastic body in the four directions through the protrusions of the pressure plate so that changes in the resistance of the pressure-sensitive electroconductive elastic body can be read from the leads.

[0009]

[Embodiments]

(Embodiment 1)

Embodiment 1 of the present invention is described hereafter with reference to the drawings.

[0010]

In Figure 1 (a)-(d), 19-22 indicate four independent secure contact points arranged in four directions; 23-26 represent leads drawn from the secure contact points 19-22; 27a, 27b, 27c, and 27d represent common secure contact points respectively facing the four independent secure contact points 19-22; no. 28 represents a lead drawn from the common secure contact points, and which are attached to a lower film 29. Above the four independent secure contact points 19-22 provided are the tips 31a, 30b, 30c, and 30d of a pressure-sensitive electroconductive elastic body 30 made of a pressure-sensitive electroconductive rubber that is coated with an electroconductive material to form an electroconductive

coating 33 on the pressure operating side opposite to the side that is in contact with the secure contact points 19-22.

[0011]

Furthermore, a pressure plate 31 having protrusions in four directions for pressing the pressure-sensitive electroconductive elastic body 30 on the secure contact points 19-22 and an operating lever 32 placed on the pressure plate 31 for pressing the pressure plate 31 in the direction of applied force are provided. As shown in the equivalent circuit, measurements of resistances between the lead 28 and the leads 23-26 provide changes in resistance between the individual contact points.

[0012]

The operation of the pressure-sensitive switch having the above structure is described hereafter with reference to Figure 2.

[0013]

When the operating lever 32 is pressed by a force in the arrowed direction A, forces B are applied to four protrusions of the pressure plate in accordance with the pressed position and in the arrowed direction B. Particularly, the pressure-sensitive electroconductive elastic body 30 receives the downward forces B_1 and B_2. Therefore, measurements of the resistance between the top and bottom of the tips 30a, 30b, 30c, and 30d of the pressure-sensitive electroconductive elastic body provide information on in which direction and of what magnitude the forces is applied, namely the "direction" and "magnitude" of the force. The resistance is decreased as shown in the equivalent circuit output property of Fig.5. Measurements of the resistance of the pressure-sensitive electroconductive elastic body 30 provide the pressure; for example, the pressure is 200 g when the pressure-sensitive electroconductive elastic body 30 has a resistance of 6 KΩ through the thickness.

[0014]

As described above, in this embodiment, a thin electroconductive coating 33 is formed on the top surface of the pressure-sensitive electroconductive elastic body 30, for example, by printing. The prior art upper film is eliminated and the pressure-sensitive

electroconductive elastic body 30 is directly pressed, improving the pointing device sensitivity.

[0015]

(Embodiment 2)

Embodiment 2 of the present invention is described hereafter with reference to the drawings.

[0016]

In Figure 3, 41a and 42a represent a pair of facing secure contact points that are insert molded in a switch case 43 and conductive to output terminals 41b and 42b, respectively. Above the secure contact points 41a and 42a provided is a pressure-sensitive electroconductive elastic body 44 coated with an electroconductive material to form an electroconductive coating 44a on the pressure operating side opposite to the side that is in contact with the secure contact points 41a and 42a. Above it, a dome-shaped elastic body 45 having a push button part 45a, a pressing part 45b, and a peripheral supporting part 45c is provided. The dome-shaped elastic body 45 is held and covered with a cover 46.

[0017]

The operation of the pressure-sensitive switch having the above structure is described hereafter with reference to Figure 3.

[0018]

When the push button part 45a of the dome-shaped elastic body 45 is pressed down, the pressing part 45b makes contact with the pressure-sensitive electroconductive elastic body 44 around the center. Upon further pressing, the pressure-sensitive electroconductive elastic body 44 is clamped and pressed by the secure contact points 41a and 42a and the push button part 45a through the thickness. Consequently, the resistance through the thickness of the pressure-sensitive electroconductive elastic body 44 is gradually decreased in accordance with the pressure as shown in the equivalent circuit output property of

Figure 6 and, finally, the output terminals 41a and 42b become conductive. Then, an electric current path 42b-42a-44-44a-44-41a-41b is established.

[0019]

As described above, in this embodiment, the output resistance is changed in accordance with the pressure applied by pressing the push button part 45a while the prior art push-switch is provided with metal contact points capable of detecting only the state ON/OFF in place of the pressure-sensitive electroconductive elastic body 44. Then, the present invention can be used as a multistage switch when connected to a voltage comparator or an A/D converter.

[0020]

(Embodiment 3)

Embodiment 3 of the present invention is described hereafter with reference to the drawings.

[0021]

In Figure 4, 51a and 52a represent a pair of secure contact points that are insert molded in a switch case 53 and conductive to output terminals 51b and 52b, respectively. Above the secure contact points 51a and 52a provided is a pressure-sensitive electroconductive elastic body 54 coated with an electroconductive material to form an electroconductive coating 54a on the pressure operating side opposite to the side is in contact with the secure contact points 51a and 52a. Above it, a dome-shaped elastic body 55 having a push button part 55a, a pressing part 55b, and a peripheral supporting part 55c is provided. The dome-shaped elastic body 55 is clamped by a cover 56. Therefore, the peripheral supporting part 55c receives a large load and has a small resistance through the thickness, then making it conductive through the thickness.

[0022]

The operation of the pressure-sensitive switch having the above structure is described hereafter with reference to Figure 4. When the push button part 55a of the dome-shaped

elastic body 55 is pressed down, the pressing part 55b makes contact with the pressure-sensitive electroconductive elastic body 54 around the center. Upon further pressing, the pressure-sensitive electroconductive elastic body 54 is clamped and pressed by the secure contact points 51a and the pressing part 55b through the thickness. Consequently, the resistance through the thickness of the pressure-sensitive electroconductive elastic body 54 is gradually decreased in accordance with the applied pressure as shown in the equivalent circuit output property of Figure 6 and, finally, the output terminals 51b and 52b become conductive. Then, an electric current path 51b-51a-54-54a-54-52a-52b is established.

[0023]

As described above, in this embodiment, the pressure-sensitive electroconductive elastic body 54 above the secure contact points 52a is clamped by the cover 56 via the peripheral supporting part 55c of the dome-shaped elastic body 55 and the resistance of the pressure-sensitive electroconductive elastic body 54 at this part is substantially decreased. Therefore, the change in resistance of the pressure-sensitive electroconductive elastic body 54 only at one area above the secure contact points 51a is supplied between the output terminals 51b and 52b. This allows more stable detection of the applied pressure. Then, the present invention can be used as a multistage switch when connected to a voltage comparator or an A/D converter.

[0024]

The pressure-sensitive electroconductive elastic body can be a rubber, resin, or insulating film that is coated with a pressure-sensitive electroconductive material to form an electroconductive coating thereon.

[0025]

[Efficacy of the invention]

As described above, the present invention uses a pressure-sensitive electroconductive elastic body that is coated with an electroconductive material to form an electroconductive coating on the pressure operating side opposite to the side that is in contact with the secure contact points. Therefore, because a pressure is directly applied to the pressure-

sensitive electroconductive elastic body by the pressing part, higher pressure detection sensitivity can be obtained compared to the prior art structure using an upper film.

[0026]

Furthermore, a push switch using as a movable contact point the pressure-sensitive electroconductive elastic body that is coated with an electroconductive material to form an electroconductive coating thereon can serve as a multistage switch, which is not available from the prior art structure. In addition, with the pressure-sensitive electroconductive elastic body being used in place of movable contact points of the prior art push switch, an excellent pressure-sensitive switch that can be assembled in an automated prior art push switch assembly machine and allows a significantly reduced number of production steps can be realized.

[Brief explanation of the drawings]

[Figure 1]

(a) A side view of the pressure-sensitive switch according to Embodiment 1 of the present invention.
(b) A plane view of the pressure-sensitive electroconductive elastic body of Embodiment 1.
(c) A plane view of the lower film of Embodiment 1.
(d) An illustration showing an equivalent circuit of the pressure-sensitive switch of Embodiment 1.

[Figure 2]

A perspective view to explain the operation of the pressure-sensitive switch of Embodiment 1.

[Figure 3]

A cross-sectional view of the pressure-sensitive switch of Embodiment 2 of the present invention.

[Figure 4]

A cross-sectional view of the pressure-sensitive switch of Embodiment 3 of the present invention.

[Figure 5]

A graphical representation showing the equivalent circuit output property of the pressure-sensitive switches of Embodiments 1, 2, and 3 of the present invention.

[Figure 6]

(a) A side view of a prior art pressure-sensitive switch.
(b) A plane view of the upper film of the same.

(c) A bottom view of the pressure-sensitive electroconductive rubber, which is a core part, of the same.

(d) A plane view of the lower film of the same.

(e) An illustration showing an equivalent circuit of the same.

[Legend]

19, 20, 21, 22, 41a, 42a, 51a, 52a	secure contact point
30, 44, 54	pressure-sensitive electroconductive elastic body
33, 44a, 54a	electroconductive coating
45, 55	dome-shaped elastic body
45a, 55a	push button
45b, 55b	pressing part
45c, 55c	peripheral supporting part
46, 56	cover

[Figure 1]

19, 20, 21, 22	secure contact point
30	pressure-sensitive electroconductive elastic body
33	electroconductive coating

[Figure 2]

[Figure 3]

41a, 42a	secure contact point
44	pressure-sensitive electroconductive elastic body
44a	electroconductive coating
45	dome-shaped elastic body
45a	push button
45b	pressing part
45c	peripheral supporting part
46	cover

[Figure 4]

51a, 52a	secure contact point
54	pressure-sensitive electroconductive elastic body

54a	electroconductive coating
55	dome-shaped elastic body
55a	push button
55b	pressing part
55c	peripheral supporting part
56	cover

[Figure 5]

ordinate: (voltage) resistance / approx. 5 V (1 MΩ) / 3 V (6 K) / 2.7 V (4.7 K) / approx. 0 V (15 Ω);
abscissa: (force)

[Figure 6]

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25401, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Patent Application H08-222070
"Pressure-sensitive switch"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

Roger P. Lewis

ROGER P. LEWIS

September 26, 2006

[redacted] [redacted]

公開実用 昭和61— 100844

⑲日本国特許庁（JP）　⑪実用新案出願公開

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H 01 H 13/52		Z－7337－5G	

審査請求 未請求 （全 頁）

⑭考案の名称　可変抵抗スイッチ

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㉒出　願　昭59(1984)12月7日

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[redacted] [redacted]

明細書

1．考案の名称

可変抵抗スイッチ

2．実用新案登録請求の範囲

ケース底部に設けられた一対の電極と、これらの電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないようにケースに支持され、押圧により曲率中心を通る母線方向が直角方向に変化する弾性導電曲面板とを有し、さらに、前記曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンを備えていることを特徴とする可変抵抗スイッチ。

3．考案の詳細な説明

（産業上の利用分野）

本考案はスイッチのオン、オフ機能の切換動作を指先の押圧感覚で容易に判断することができる可変抵抗スイッチに関し、スイッチの押しボタンの押し具合で2つの端子間の抵抗値を変化させることができる可変抵抗スイッチに関す

る。

〔従来の技術〕

従来の感圧素子、特に感圧導電性ゴムを使用した可変抵抗スイッチは、スイッチケースの底部に一対の電極が敷設され、その上に載置された感圧導電性ゴムの上面を押しボタンで押圧することによる感圧導電性ゴムの抵抗値の変化を利用するのが一般的である。

ところが、このような可変抵抗スイッチについては、オフ状態で押しボタンを押した時に、オン状態から可変抵抗機能を働かせるまでの動作中に、いつオン状態となったかの切換節度（クリックアクション）がなく、押しボタンの操作者にとってこのスイッチが使いづらいものとなることが多かった。

〔考案の目的〕

本考案の目的は前記従来の可変抵抗スイッチの有する欠点を解消し、押圧操作時にオフ状態からオン状態に切り換わったことが操作者に明確に判断できるように、押しボタンのストロー

[redacted] [redacted]

グの途中に切換点（クリックポイント）を持たせた優れた可変抵抗スイッチを提供することである。

〔考案の構成〕

前記目的を達成する本考案の可変抵抗スイッチは、ケース底部に設けられた一対の電極と、これらの電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないようにケースに支持され、押圧により曲率中心を通る母線方向が直角方向に変化する弾性導電曲面板とを有し、さらに、前記曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンを備えていることを特徴としている。

〔実施例〕

以下添付図面を用いて本考案の実施例を説明する。

第1図および第2図は本考案の可変抵抗スイッチ10の一実施例の構造を示す互いに直交する方向の縦断面図である。

この実施例の可変抵抗スイッチ10は、下部スイッチケース5と、これを覆う上部スイッチケース2と、この上部スイッチケース2の上側に露出する押しボタン1とを備えている。そして、前記下部スイッチケース5の底部には、一対の電極4A，4Bが所定の間隙を隔てて敷設されており、両電極4A，4Bの端部はそれぞれ端子7A，7Bによって下部スイッチケース5の底部外に突出している。

前記両電極4A，4Bの上には、これら両電極4A，4Bに跨るように均一厚の平板状感圧導電性ゴム6が載置されており、この感圧導電性ゴム6の上方に弾性導電曲面板3が非接触状態で位置している。前記感圧導電性ゴム6は圧力に応じて抵抗値が変化するものであり、無負荷状態では前記電極4A，4Bを絶縁状態に保つようになっている。

また、前記弾性導電曲面板3は、第3図に示すようにその長手方向両端部が上方に湾曲して凹面が上を向いた形状をしており、その曲率中

[redacted] [redacted]

心を通る母線8の両端部が前記下部スイッチケース5の側面に形成された段部5Aに載置状態で支持されている。この段部5Aは弾性導電曲面板3の上面より上方にあり、このために、前記弾性導電曲面板3は感圧導電性ゴム6に非接触の状態にあるのである。

前記弾性導電曲面板3は、例えばばね性を有する80μ程度のリン青銅で形成されており、凹面側から矢印Fで示す力で母線8の中心を押圧した場合、この凹面は弾性変形を起こし、クリックアクションで前記凹面の向きが変化し、母線8の方向は第4図に母線9で示すように直角方向に変化する。

この時、前記弾性導電曲面板3の底面3Aが前記感圧導電性ゴム6に接触するように、この弾性導電曲面板3は前記段部5Aによって感圧導電性ゴム6の上面から離されている。

また、この実施例では弾性導電曲面板3は長手方向両端部が上方に湾曲しているが、下方に湾曲していてもこのクリックアクションは得ら

れる。

　このような弾性導電曲面板３の上方には、前記押しボタン１の下端が当接あるいは近接した状態で位置している。この押しボタン１は、その胴部１Ｂが前記上部スイッチケース２に形成されたガイド２Ａ内に上下に摺動自在に挿入されており、上端の拡開された頭部１Ａがガイド２Ａの上部に露出している。１Ｃはこの押しボタン１の前記ガイド２Ａからの抜けを防止する係止段部である。

　以上のように構成された本考案の可変抵抗スイッチ10を動作させる時は、押しボタン１を下方に押圧するとその下端が弾性導電曲面板３を下方に押圧する。弾性導電曲面板３はこの押圧により、長手方向両端部が上方に湾曲した状態から平面状態を経由して、短手方向両端部が上方に湾曲した状態に変化し、クリックアクションを生じる。そして、前述のように弾性導電曲面板３はクリックアクションを生じた時点で、その下方に位置する感圧導電性ゴム６に接し、

[redacted] [redacted]

電流が一方の端子７Ａから感圧導電性ゴム６を介して弾性導電曲面板３を通り、更に感圧導電性ゴム６を介して他方の端子７Ｂへと流れることができるようになる。この状態が本考案の可変抵抗スイッチ10のオン動作開始点である。

さらに押しボタン１を押圧すると、感圧導電性ゴム６が圧縮されてその抵抗値が減るので、端子７Ａ－端子７Ｂ間の抵抗値は徐々に減少する。そして、前述の押圧動作をやめると、弾性導電曲面板３の復元力によって押しボタン１が押し上げられ、弾性導電曲面板３は無負荷時の状態の位置に戻って感圧導電性ゴム６には接触しなくなるので、端子７Ａ－端子７Ｂ間の抵抗値は無限大を示す。

本考案の可変抵抗スイッチ10は以上のように動作するので、弾性導電曲面板３の形状変化によるスイッチ切換動作が押圧感覚で容易に押しボタン１を押す操作者に理解でき、また、押圧力と抵抗値との変化特性も弾性導電曲面板３の形状を調整することにより制御することが可能

である。さらにまた、弾性導電曲面板3を用いることにより、感圧導電性ゴム6を流れる電流を流れにくい平面方向の電流から感圧導電性ゴム6の厚さ方向への電流に変化することができる。そして、電極4A，4Bの端子7A，7Bを下部スイッチケース5の下方から取り出すことができるので、容易に可変抵抗スイッチ10の組立ができ、そして、コンパクトな素子を提供することが可能である。

〔考案の効果〕

以上説明したように本考案の可変抵抗スイッチは、ケース底部に設けられた一対の電極と、これらの電極上に載置された平板状感圧導電性ゴムと、この感圧導電性ゴム上面に接触しないようにケースに支持され、押圧により曲率中心を通る母線方向が直角方向に変化する弾性導電曲面板とを有し、さらに、前記曲面板に下端が当接あるいは近接し、上端が前記ケースから露出する押しボタンを備えていることにより、押圧操作時にオフ状態からオン状態に切り換わっ

[redacted] [redacted]

たことが操作者に明確に判断できるという効果がある。また、クリック機能を有する弾性導電曲面板を使用したことにより、押圧力に応じた抵抗値の変化の特性を調整することができるという利点がある。

4．図面の簡単な説明

第1図は本考案の可変抵抗スイッチの一実施例の縦断面図、第2図は第1図のII－II線における縦断面図、第3図は本考案の可変抵抗スイッチに使用する弾性導電曲面板の斜視図、第4図は第3図の弾性導電曲面板の押圧による変形状態を示す斜視図である。

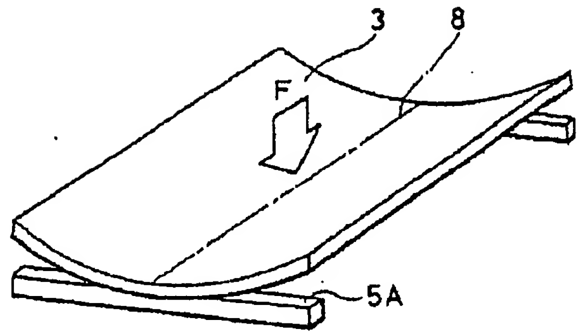
1…押しボタン、2…上部スイッチケース、3…弾性導電曲面板、4A，4B…電極、5…下部スイッチケース、6…感圧導電性ゴム、7A，7B…端子、8，9…母線、10…本考案の可変抵抗スイッチ。

代理人　弁理士　小　川　信　一
　　　　弁理士　野　口　賢　照
　　　　弁理士　斎　下　和　彦

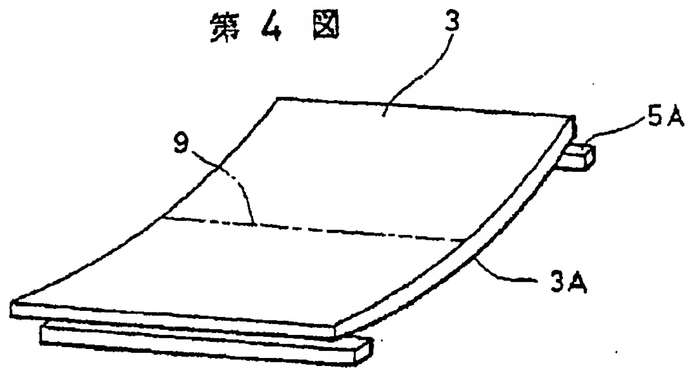
410

[redacted] [redacted]

第 3 図



第 4 図



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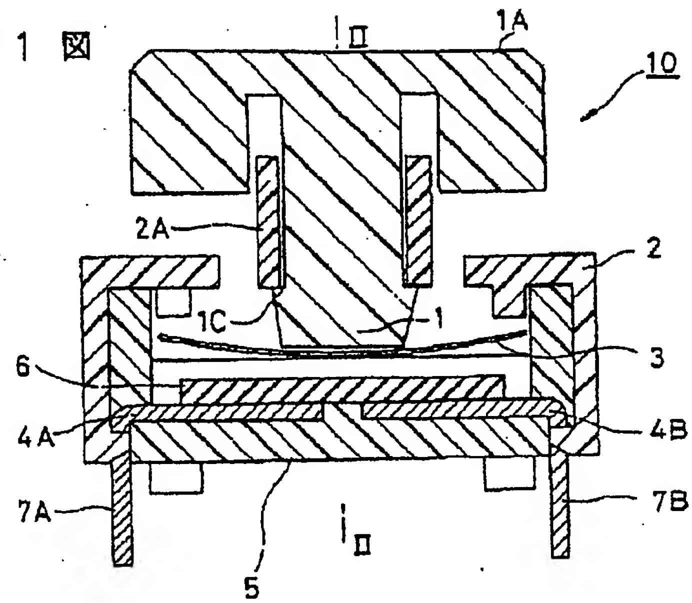
第 1 図



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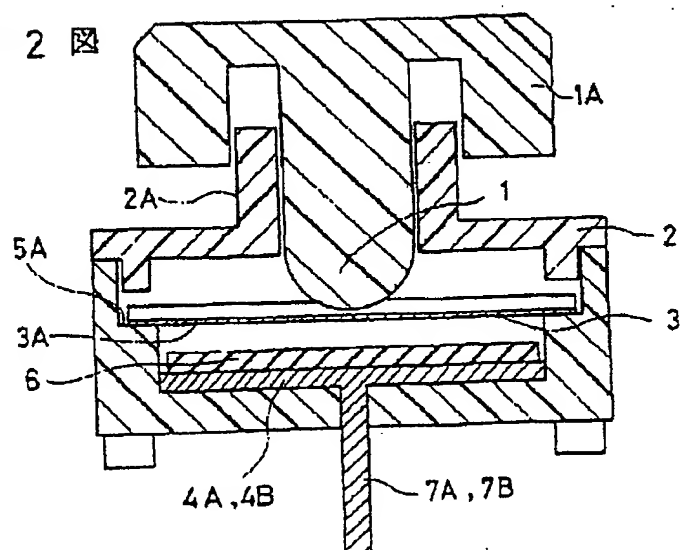

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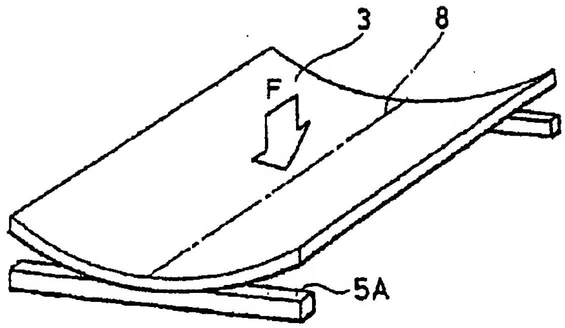
第3図



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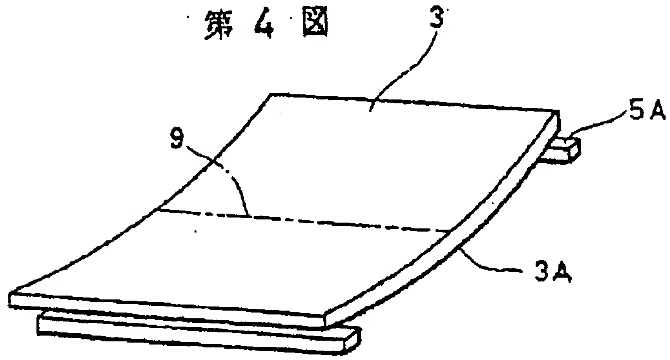

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Specification

1. Title of the invention
   Variable resistance switch

2. Utility Model Registration Claims

A variable resistance switch comprising a pair of electrodes provided at the bottom of a case, a flat plate of pressure-sensitive electro-conductive rubber provided on said electrodes, and an elastic electro-conductive curved plate supported by said case so that it is not in contact with the top surface of said pressure-sensitive electro-conductive rubber and of which the generation line direction passing through the center of curvature is changed orthogonally in response to pressure, characterized by further comprising a push button having a bottom end abutting or residing near said curved plate and a top end exposed from said case.

3. Detailed explanation of the invention

[Scope of the invention]

The present invention relates to a variable resistance switch in which on/off switching can be easily recognized through the feeling of pressure on a fingertip and the resistance between two terminals can be changed depending on how far the push button of the switch is pressed.

[Prior art technology]

Prior art pressure-sensitive elements, particularly variable resistance switches using pressure-sensitive electro-conductive rubber comprise a pair of electrodes at the bottom of a switch case and a pressure-sensitive electro-conductive rubber on top of it wherein the pressure-sensitive electro-conductive rubber is pressured at the top surface through a push button to change the resistance of the pressure-sensitive electro-conductive rubber.

In such a variable resistance switch, when the push button is pressed while the switch is off, there is no switchover point (click action) to indicate when it is turned on in the course of operation to activate the variable resistance function from the off-state. Hence, the operator of the push button often experiences difficulty in using such a switch.

[Purpose of the invention]

The purpose of the present invention is to resolve the above problems with the prior art variable resistance switch and to provide an excellent variable resistance switch in which a switchover point (click point) is provided in the middle of the stroke of the push button so that the operator clearly recognizes the switching from the off-state to the on-state in the course of the pressing operation.

[Structure of the invention]

In order to achieve the above purpose, the variable resistance switch of the present invention comprises a pair of electrodes provided at the bottom of a case, a flat plate of pressure-sensitive electro-conductive rubber provided on the electrodes, and an elastic electro-conductive curved plate supported by the case so that it is not in contact with the top surface of the pressure-sensitive electro-conductive rubber and of which the generation line direction through the center of curvature is orthogonally changed in response to pressure, characterized by further comprising a push button having a bottom end abutting or residing near the curved plate and a top end exposed from the case.

[Embodiments]

An embodiment of the present invention is described hereafter with reference to the drawings.

Figs. 1 and 2 are cross-sectional views in directions orthogonal to each other showing the structure of a variable resistance switch 10 according to an embodiment of the present invention.

The variable resistance switch 10 of this embodiment comprises a lower switch case 5, an upper switch case 2 covering it, and a push button 1 exposed above the upper switch case 2. A pair of electrodes 4A and 4B is provided at the bottom of the lower switch case 5 at a specific distance. The ends of the electrodes 4A and 4B protrude from the bottom of the lower switch case 5 as terminals 7A and 7B.

On the electrodes 4A and 4B provided is a flat plate of pressure-sensitive electro-conductive rubber 6 having a uniform thickness to link the electrodes 4A and 4B together. An elastic electro-conductive curved plate 3 is provided above the pressure-sensitive electro-conductive rubber 6 with no contact. The pressure-sensitive electro-conductive rubber 6 has variable resistance according to the pressure. The electrodes 4A and 4B are insulated from each other under no load.

With the longitudinal ends being curved upward, the elastic electro-conductive curved plate 3 has a concave surface facing upward as shown in Fig.3.

It is supported by steps 5A formed on the sidewalls of the lower switch case 5 at either end of the generating line 8 passing through the center of curvature resting thereon. The steps 5A are at a higher level than the top surface of the elastic electro-conductive curved plate 3. Therefore, the elastic electro-conductive curved plate 3 is not in contact with the pressure-sensitive electro-conductive rubber 6.

The elastic electro-conductive curved plate 3 is, for example, made of a phosphor bronze of approximately 80 μ having spring-like properties. When pressed at the center of the generating line 8 on the concave surface side with the force indicated by an arrow F, the concave surface is elastically deformed and changes its orientation with a click action. The generating line 8 changes its orientation orthogonally to the generating line 9 shown in Fig.4.

The elastic electro-conductive curved plate 3 is spaced from the pressure-sensitive electro-conductive rubber 6 by the steps 5A so that the bottom surface 3A of the electro-conductive curved plate 3 makes contact with the pressure-sensitive electro-conductive rubber 6 in the above process.

In this embodiment, the elastic electro-conductive curved plate 3 has the longitudinal ends curved upward. However, the longitudinal ends curved downward yield the same click action.

A push button 1 is provided above the elastic electro-conductive curved plate 3 with the bottom end abutting or residing near it. The push button 1 has a body 1B that is vertically slidably inserted in a guide 2A formed in the upper switch case 2 and head 1A having an extended top and exposed above the guide 2A. The number 1C represents an engaging step for preventing the push button 1 from coming out of the guide 2A.

For operating the variable resistance switch 10 of the present invention having the above structure, the push button 1 is pressed down so that its bottom end presses the elastic electro-conductive curved plate 3 downward. With this pressing, the elastic electro-conductive curved plate 3 changes its state from one in which the longitudinal ends are curved upward to the other in which the transverse ends are curved upward via a flat state. This is a click action. When the elastic electro-conductive curved plate 3 undergoes the click action described above, it makes contact with the pressure-sensitive electro-conductive rubber 6 below it.

Then, an electric current flows from one terminal 7A to the elastic electro-conductive curved plate 3 via the pressure-sensitive electro-conductive rubber 6 and further to the other terminal 7B via the pressure-sensitive electro-conductive rubber 6. In this state, the variable resistance switch 10 of the present invention is at the switch-on start point.

With the push button 1 being further pressed, the pressure-sensitive electro-conductive rubber 6 is compressed and has reduced resistance, which gradually reduces the resistance between the terminals 7A and 7B. When pressing is discontinued, the restoration of the elastic electro-conductive curved plate 3 pushes up the push button 1 and the elastic electro-conductive curved plate 3 returns to the no-load state so that it is no longer in contact with the pressure-sensitive electro-conductive rubber 6, with the resistance between the terminals 7A and 7B reaching an infinite value.

The variable resistance switch 10 of the present invention operates as described above. The operator pressing the push button 1 can easily recognize through the feeling of pressure the switching operation as a result of the change in shape of the elastic electro-conductive curved pate 3. Furthermore, the characteristic change in pressure and resistance can be controlled by changing the shape of the elastic electro-conductive curved plate 3.

(7)

Furthermore, the elastic electro-conductive curved plate 3 is used to change the direction of the current flow through the pressure-sensitive electro-conductive rubber 6 from the horizontal direction in which an electric current is sluggish to the thickness direction. The terminals 7A and 7B of the electrodes 4A and 4B can be removed from the bottom of the lower case 5. Hence, an easily assembled and compact variable resistance switch can be obtained.

[Effects of the invention]

As described, the variable resistance switch of the present invention comprises a pair of electrodes provided at the bottom of a case, a flat plate of pressure-sensitive electro-conductive rubber provided on the electrodes, and an elastic electro-conductive curved plate supported by the case so that it is not in contact with the top surface of the pressure-sensitive electro-conductive rubber and of which the generation line direction passing through the center of curvature is changed orthogonally in response to pressure, and further comprises a push button having a bottom end abutting or residing near the curved plate and a top end exposed from the case.

The present invention has the efficacy that the operator can clearly recognize switching from the off-state to the on-state in the course of the pressing operation. Furthermore, using an elastic electro-conductive curved plate having a click function, the characteristic change in resistance according to the pressure can be adjusted.

4. Brief explanation of the drawings

Fig. 1 is a vertical cross-sectional view of an embodiment of the variable resistance switch of the present invention. Fig.2 is a vertical cross-sectional view at the line II-II in Fig.1. Fig.3 is a perspective view of the elastic electro-conductive curved plate used in the variable resistance switch of the present invention. Fig.4 is a perspective view of the elastic electro-conductive curved plate of Fig.3 when it is deformed by pressing.

1 ... push button, 2 ... upper switch case, 3 ... elastic electro-conductive curved plate, 4A, 4B ... electrode, 5 ... lower switch case, 6 ... pressure-sensitive electro-conductive rubber, 7A, 7B ... terminal, 8, 9 ... generating line, 10 ... variable resistance switch of the present invention.

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Laid-Open Utility Model S61-100844

Fig.1

Fig.2

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Fig.3
Fig.4

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CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25405, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Laid Open Utility Model

JP S61-100844
"Variable Resistance Switch"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

October 24, 2006

[redacted] [redacted]

⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　平3-61304

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審査請求　未請求　請求項の数 1　（全　頁）

㊾考案の名称　可変抵抗器

㉑実　願　平1-122957
㉒出　願　平1(1989)10月20日

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明細書

1．考案の名称

可変抵抗器

2．実用新案登録請求の範囲

弾性材料からなる作動体の被押圧部の押圧変形に伴って電極部の導通抵抗が変化する抵抗器本体と、被押圧部を押圧可能な押圧部を備えた操作体とからなる可変抵抗器において、

作動体の被押圧部に隣接して、被押圧部よりも高さ寸法が大きく、且つ上端を操作体の押圧部に当接する弾性材料からなるガタ防止用突起を立設した

ことを特徴とする可変抵抗器。

3．考案の詳細な説明

（産業上の利用分野）

本考案は、操作体を介しての被押圧部の押圧変形に伴って電極部の導通抵抗が変化する可変抵抗器の改良に関し、特に操作体のガタつきを防止できる可変抵抗器に関するものである。

（従来の技術）

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従来、この種の可変抵抗器として第４図に示すものが知られている。

この可変抵抗器は２つの電極部を有するシーソータイプのもので、抵抗器本体２０と、押圧操作用の操作体３０とから構成されている。

抵抗器本体２０は、押圧操作を受ける作動体２１と、押え板２２と、基板２３とからなる。

作動体２１は合成ゴム等の弾性材料から矩形板状に形成され、山形の被押圧部２１ａをその上面に２個有している。各被押圧部２１ａは上端を平坦に形成されており、その上面中央に操作体３０のガタを防止するための突起２１ａ１を有している。また、作動体２１の下面側には、導電ゴム等からなる円板状の導電部２１ｂが各突部と対応して同軸上に付設されている。

押え板２２は作動体２１の上面を覆うもので、各被押圧部２１ａが挿通する孔２２ａを上面に有し、且つ作動体２１の上面周縁に当接する押え面２２ｂを内側に有している。また、押え板２２の下面には基板２３の厚さよりも長い係止ピン２２

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ｃが複数本形成されている。

基板２３はプリント配線板等からなり、その上面に、作動体２１の導電部２１ｂが接触可能な電極部２３ａを２箇所に有している。この電極部２３ａとしては、一対の電極の上面に感圧導電ゴム等の感圧導電材を付設したものが使用されている。また、基板２３には押え板２２の係止ピン２２ｃが挿入可能な係止孔２３ｂが形成されている。

この抵抗器本体２０は、作動体２１を基板２３上に載置し、該作動体２１を覆うようにして押え板２２の係止ピン２２ｃを基板２３の係止孔２３ｂに挿入し、基板２３の下面から突出した係止ピン２２ｃの突出部分を溶融または圧潰して押え板２２を基板２３に固定することで組立てられる。この組立状態において作動体２１は押え板２２と基板２３との間で不動に挟持され、作動体２１の導電部２１ｂと基板２３の電極部２３ａとは接触している。

一方、操作体３０は、抵抗器本体２０の上方において、中央下部に設けられた軸３１を図示省略

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のブラケット等によって回転自在に軸支されている。また、操作体３０は作動体２１の各被押圧部２１ａに夫々対応する押圧部３２を下面に有しており、各押圧部３２には非押圧状態で被押圧部２１ａ上面のガタ防止用突起２１ａ１が夫々当接している。

このように構成された可変抵抗器では、操作体３０の軸３１を中心とする傾動によって作動体２１の被押圧部２１ａが下方に押圧されて変形した時に、該押圧力に伴って電極部２３ａの導通抵抗が変化するようになっている。

（考案が解決しようとする課題）

ところで、従来の可変抵抗器では、操作体３０を取付けた状態で、該操作体３０の押圧部３２と作動体２１の被押圧部２１ａとの間に形成される隙間を、ガタ防止用突起２１ａ１によって吸収させているが、該突起２１ａ１を被押圧部２１ａの上面（被押圧面）に形成しているため、突起自体の高さ寸法にプラス側の誤差があると被押圧部２１ａが非押圧状態で不当な押圧力を受け、可変抵

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抗器に所期の抵抗変化を得られなくなるという問題点があった。また、突起自体の高さ寸法にマイナス側の誤差があるとそれまでと同様に隙間が形成されて操作体３０にガタつきを生じるという問題点があった。

本考案は前記問題点に鑑みてなされたもので、その目的とするところは、可変抵抗器の抵抗値特性に支障を生じることなく、操作体のガタつきを確実に防止できる可変抵抗器を提供することにある。

（課題を解決するための手段）

本考案は前記目的を達成するために、弾性材料からなる作動体の被押圧部の押圧変形に伴って電極部の導通抵抗が変化する抵抗器本体と、被押圧部を押圧可能な押圧部を備えた操作体とからなる可変抵抗器において、作動体の被押圧部に隣接して、被押圧部よりも高さ寸法が大きく、且つ上端を操作体の押圧部に当接する弾性材料からなるガタ防止用突起を立設している。

（作　用）

本考案によれば、被押圧部とは異なる位置に、被押圧部よりも高さ寸法が大きく、且つ上端を操作体の押圧部に当接する弾性材料からなるガタ防止用突起を立設しているので、該突起の高さ寸法をマイナス側の誤差分を考慮して大きめに形成しておいても、操作体の非押圧状態において被押圧部に不当な押圧力が加わることがない。

（実施例）

第１図乃至第３図は本考案をシーソータイプの可変抵抗器に適用した実施例を示すもので、第１図は可変抵抗器の断面図、第２図は抵抗器本体の上面図、第３図は動作説明図である。

第１図及び第２図に示した本実施例の可変抵抗器は、抵抗器本体１と、押圧操作用の操作体１０とから構成されている。

抵抗器本体１は、押圧操作を受ける作動体２と、押え板３と、基板４とからなる。

作動体２は合成ゴム等の弾性材料から矩形板状に形成され、上端が平坦な山形の被押圧部２ａをその上面に２個有している。また、作動体２の下

面側には、導電ゴム等からなる円錐状の導電部2bが各突部2aに対応して同軸上に付設されている。更に、作動体2の上面には、各被押圧部2aに隣接して、被押圧部2aよりも高さ寸法の大きなガタ防止用の棒状突起2cが夫々垂直に、且つ作動体2と一体に立設されている。

押え板3は作動体2の上面を覆うもので、各被押圧部2a及び各棒状突起2cが挿通する略円形の孔3aを上面に有し、且つ作動体2の上面に当接する押え面3bを内側に有している。また、押え板3の各辺夫々には、基板4の厚さよりも長く、且つ下端に鉤形係止部を有する係合片3cが垂設されている。

基板4はプリント配線板等からなり、その上面に、作動体2の導電部2bが接触可能な電極部4aを2箇所に有している。この電極部4aとしては、半円形の2個の抵抗膜を非接触状態で配置し、且つ各抵抗膜に電極を接続したものが使用されている。また、基板4には、押え板3の係合片3cが挿入及び係合可能な係止孔4bが、各係合片に

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対応して形成されている。

この抵抗器本体1は、作動体2を基板4上に載置し、該作動体2を覆うようにして押え板3の係合片3cを基板4の係止孔4bに挿入して係止させることで簡単に組立てられる。この組立状態において作動体2は押え板3と基板4との間で不動に挟持され、作動体2の導電部2bと基板4の電極部4aとは所定間隔をおいて対峙している。

一方、操作体10は、抵抗器本体1の上方において、中央下部に設けられた軸11を図示省略のブラケット等によって回転自在に軸支されている。また、操作体10は作動体2の各被押圧部2aに夫々対応する矩形状の押圧部12を下面に有しており、各押圧部32には非押圧状態でガタ防止用棒状突起2cの上端が夫々当接している。

次に第3図を参照して前述の可変抵抗器の動作について説明する。

図において操作体10の上面左側を指先等で押圧し、該操作体10を軸11を中心として反時計回り方向に傾動させると、まず左側の押圧部12

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に当接するガタ防止用棒状突起２ｃが撓み、やがて該押圧部１２が被押圧部２ａの上面に当接して被押圧部２ａが下方に押圧されて変形し、被押圧部２ａの下面側の導電部２ｂが電極部４ａに接触する。導電部２ｂの接触面積は押圧力に伴って増加し、これにより電極部２３ａの導通抵抗が変化する。

操作体１０への押圧を解けば、作動体２の被押圧部２ａ及びガタ防止用棒状突起２ｃは自らの弾性で夫々元の状態に復元し、操作体１０は再び棒状突起２ｃによって下面を支持されそのガタつきが防止される。

このように前述の可変抵抗器では、作動体２の上面に各被押圧部２ａに隣接して該被押圧部２ａよりも高さ寸法の大きなガタ防止用の棒状突起２ｃを立設し、且つその上端を操作体１０の各押圧部１２に当接しているので、ガタ防止用棒状突起２ｃの高さ寸法にプラス側の誤差を生じた場合でも、該棒状突起２ｃが多少撓む程度で、被押圧部２ａには非押圧状態で不当な押圧力が加わること

がなく、これにより可変抵抗器に所期の抵抗変化を得ることができる。また、ガタ防止用棒状突起２ｃの高さ寸法をマイナス側の誤差分を考慮して予め大きめに形成しておくことが可能になるので、棒状突起２ｃの上端を操作体１０の押圧部１２に的確に当接させて操作体１０のガタつきを確実に防止することができる。

尚、前記実施例ではシーソータイプの可変抵抗器に本考案を適用したものを示したが、被押圧部が1個または3個以上の他のタイプの可変抵抗器チでも本考案を適用できることは勿論である。また、電極部４ａとして抵抗膜を用いたものを示したが、従来例と同様の感圧導電材を用いた電極部を使用してもよい。更に、ガタ防止用の突起を棒状に形成したものを示したが、該突起の形状は押圧部に当接し、且つガタを防止できるものであれば種々採用できる。

（考案の効果）

以上詳述したように、本考案によれば、ガタ防止用突起の高さ寸法にプラス側の誤差を生じた場

[redacted] [redacted]

合でも、該突起が多少撓む程度で、作動体の被押圧部には非押圧状態で不当な押圧力が加わることがなく、これにより可変抵抗器に所期の抵抗変化を得ることができる。また、ガタ防止用突起の高さ寸法をマイナス側の誤差分を考慮して予め大きめに形成しておくことが可能になるので、該突起の上端を操作体の押圧部に的確に当接させて操作体のガタつきを確実に防止することができる。

4．図面の簡単な説明

第1図乃至第3図は本考案をシーソータイプの可変抵抗器に適用した実施例を示すもので、第1図は可変抵抗器の断面図、第2図は抵抗器本体の上面図、第3図は動作説明図、第4図は従来の可変抵抗器の断面図である。

図中、1…抵抗器本体、2…作動体、2a…被押圧部、2c…ガタ防止用の棒状突起、4a…電極部、10…操作体、12…押圧部。

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[redacted]

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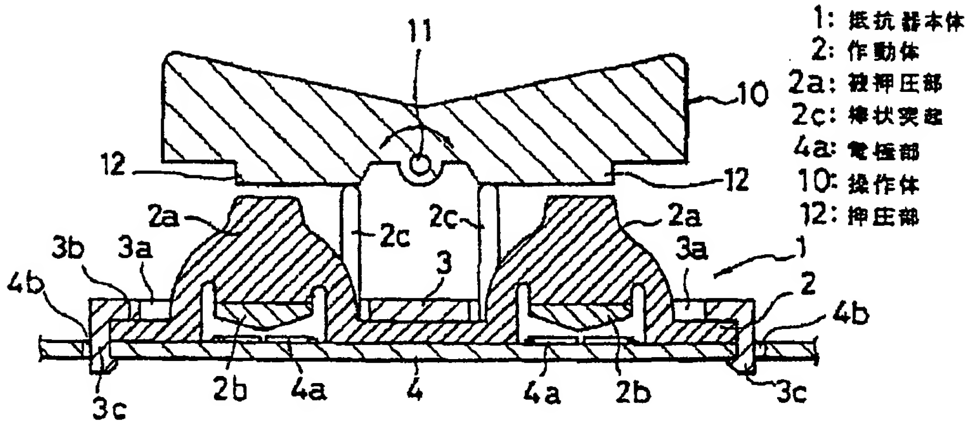
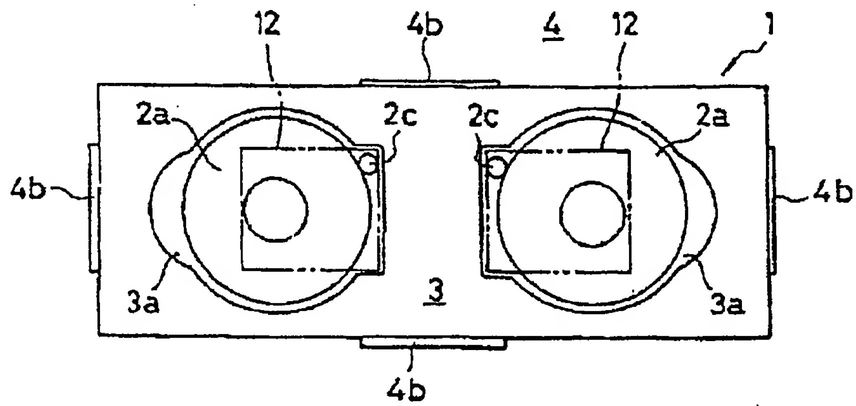
公開実用平成 3−61304



可変抵抗器の断面図

第 1 図



抵抗器本体の上面図

第 2 図

39

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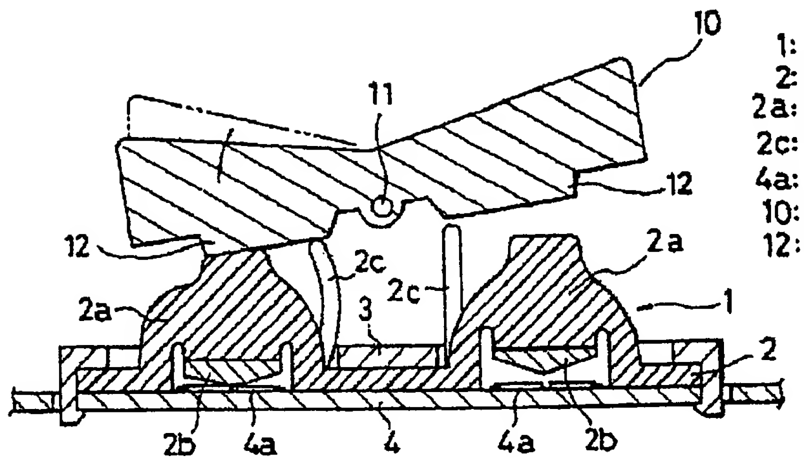
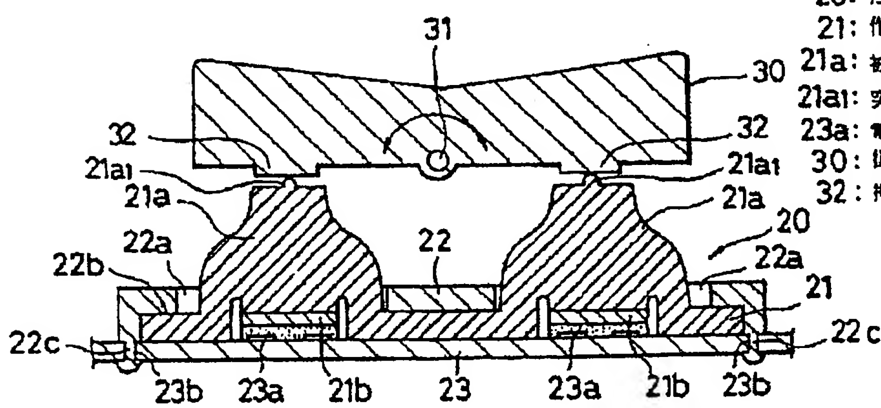


動作説明図

第3図



従来の可変抵抗器の断面図

第4図

40

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[redacted]

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(54) Title of the Design

VARIABLE RESISTOR

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Specification

1. Title of the design

Variable Resistor

2. Claims

A variable resistor comprising a resistor main body for changing the conductive resistance of electrode parts with the press deformation of covered pressed parts of an acting body made of an elastic material and an operating body having pressing parts capable of pressing the pressed parts is characterized by vertically providing shake prevention projections made of an elastic material adjacent to the pressed parts of the acting body, have a larger height dimension than the pressed parts and their upper ends contacting the pressing parts of the operating body.

3. Detailed description of the design

(Field of industrial application)

The present design relates to a modification of a variable resistor for changing the conductive resistance of electrode parts with the press deformation of pressed parts via an operating body, and relates particularly to a variable resistor that may prevent shaking of the operating body.

(Prior art)

A variable resistor shown in Fig. 4 has been known as this kind of variable resistor before.

This variable resistor is a seesaw type resistor having two electrodes and is constituted from a resistor main body **20** and an operating body **30** for the press operation.

The resistor main body **20** comprises an acting body **21** receiving the press operation, a pressure plate 22 and a base board **23**.

The acting body **21** is formed of an elastic material such as synthetic rubber, etc. in the shape of a rectangular plate and has two hill-like pressed parts **21a** on its upside. The upper ends of the two hill-like pressed parts **21a** are flat and have projections **21a1** for preventing shaking of the operating body **30** at the center of its upside. Disc-like conductive parts **21b** made of a con-

ductive rubber, etc. are coaxially attached downside of acting body **21** corresponding to the projections **21a1**.

The pressure plate 22 covers the upside of acting body **21**, has holes **22a** for inserting the pressed parts **21a** on it and has pressing surface **22b** in contact with the rim upside of acting body **21** on the inner side. Multiple stop pins **22c** longer than the thickness of base board **23** are formed downside of pressure plate 22.

The base board 23 comprises a printed wiring board, etc. and has electrode parts **23a** capable of making contact with the conductive parts **21b** of acting body **21** at two locations. Electrode parts attached to pressure-sensing conductive material, such as pressure-sensing conductive rubber, etc. upside of a pair of electrodes are used as these electrode parts **23a**. Stop holes **23b** capable of inserting stop pins **22c** of pressure plate 22 are formed on the base board **23**.

The resistor body **20** is assembled by mounting the acting body **21** on the base board **23**, inserting the stop pins **22c** of pressure plate 22 into the stop holes **23b** of base board **23** so as to cover the acting body **21**, melting or collapsing the projections of the stop pins **22c** protruding downside of base board **23** to secure the pressure plate 22 to the base board **23**. In this assembled state, the acting body **21** is fixedly held between the pressure plate 22 and the base board **23**, bringing the conductive parts **21b** of acting body **21** and the electrode parts **23a** of base board **23** into contact.

On the other hand, the operating body 30 is rotatably pivoted on a shaft **31** provided in the central lower part above the resistor main body **20** by a bracket omitted in the graphical presentation. The operating body **30** has pressing parts **32** corresponding to the downside pressed parts **21a** of acting body **21**, and the projections **21a1** for shake prevention upside of pressed parts **21a** are in contact with the pressing parts **32** in the non-pressed state, respectively.

In the variable resistor thus constituted, when the pressed parts **21a** of acting body **21** are pressed downward and deformed by tilting with the shaft **31** of operating body **30** as the center, the conductive resistance of electrode parts **23a** changes with the pressure force.

(Problem overcome by the design)

In the prior variable resistor, gaps formed between the pressing parts **32** and the pressed parts **21a** of acting body **21** are absorbed by the projections **21a1** for shake prevention in the state of mounting the operating body **30**, but the projections **21a1** are formed on the upside (pressed side) of

pressed parts **21a**, therefore, if a plus-side error in height dimension of the projection themselves exists, there the problem that the pressed parts **21a** receive an improper press force in the non-pressed state, and an anticipated resistance change is not obtained in the variable resistor. Similarly, if a minus-side error in the height dimension of the projection exists, there is the problem that gaps are formed and shaking is generated in the operating body **30**.

The present design was made in view of the above problem, and its purpose is to provide a variable resistor that can reliably prevent shaking in the operating body **30** without causing a hindrance in the characteristic resistance value of the variable resistor.

(Problem resolution means)

To achieve the above purpose, the present design is a variable resistor which comprises a resistor main body for changing the conductive resistance of electrode parts with the press deformation of the pressed parts of an acting body made of an elastic material and an operating body having pressing parts capable of pressing the pressed parts and is characterized by vertically providing projections for shake prevention made of an elastic material adjacent to the pressed parts of the acting body, have a larger height dimension than the pressed parts and have their upper ends in contact with the pressing parts of the operating body.

(Functions)

According to the present design, the projections for shake prevention which have a larger height dimension than the pressed parts and their upper ends are in contact with the pressing part of the operating body are vertically provided in positions different from the pressed parts, therefore an improper pressure force is not applied to the extruded parts even if a large height dimension of the projections is formed by considering the minus-side error portion.

(Example)

Fig. 1 to Fig. 3 show an example in which the present design is applied to a seesaw type variable resistor, Fig. 1 is the sectional view of the variable resistor, Fig. 2 is the top view of a resistor main body, and Fig. 3 is the illustrative drawing of operations.

The variable resistor of this example shown in Fig. 1 and Fig. 2 is constructed from a resistor main body 1 and an operating body **10** for press operations.

The resistor main body 1 comprises an acting body 2 receiving the press operation , a pressure plate 3 and a base board 4.

The acting body 2 is formed of an elastic material such as synthetic rubber, etc. in the shape of a rectangular plate and has two hill-like pressed parts 2a with flat upper ends on its upside. Conical conductive parts 2b made of a conductive rubber, etc. are coaxially attached downside of acting body corresponding to the projections 2c (wrong number "2a"?, translator). Rod-like projections 2c for shake prevention which are adjacent to the pressed parts 2a and have a larger height dimension than the pressed parts 2a are provided vertically and integrally with the acting body 2, respectively.

The pressure plate 3 covers the upside of acting body 2, has roughly circular holes 3a, through which the pressed parts 2a and the rod-like projections 2c are inserted on the upside and have the pressing surface 3b in contact with the upside of acting body 2 on the inner side. Engagement pieces 3c which are longer than the thickness of base board 4 and have a hooklike engagement at the lower end are vertically provided at each side of the pressure plate 3.

The base board comprises a printed wiring board, etc. and has electrode parts 4a for which the conductive parts 2b of acting body 2 is contactable at two locations on its upside. Electrode parts in which two semi-circular resistance films are arranged in the non-contact state and electrodes are connected to the resistance films are used as the electrode parts 4a. Engagement holes 4b through which the engagement pieces 3c of pressure plate 3 can be inserted and engaged are formed corresponding to the engagement pieces.

This resistor main body 1 is simply assembled by mounting the acting body 2 on the base board 4, inserting the engagement pieces 3c of pressure plate 3 into the engagement holes 4b of base board 4 and stopping them so as to cover the acting body 2. In the assembled state, the acting body 2 is fixedly held between the pressure plate 3 and the base board 4, and the conductive parts 2b of acting body 2 and the electrode parts 4a of base board 4 are opposite at a prescribed spacing.

On the other hand, in the operating body 10 is rotatably pivoted above the resistor main body 1 on a shaft 11 provided in the central lower part by a bracket omitted in the graphical presentation. The operating body 10 has rectangular pressing parts 12 corresponding to the pressed parts 2a of acting body 2, respectively, the upper ends of the rod-like projections 2c for shake prevention are in contact with the pressing parts 32 in the non-extruded state, respectively.

Operations of the above-mentioned variable resistor are described next with reference to Fig. 3.

In Fig. 3, if the top left side of the operating body **10** is pressed with a finger tip, etc., the operating body **10** is tilted in the counterclockwise direction with the shaft **11** as center, first the rod-like projections **2c** for shake prevention in contact with the left-side pressing part **12** flex, shortly the pressing part **12** makes contact upside of the pressed part **2a**, the pressed part **2a** is pressed down and deformed, and the conductive parts **2b** on the downside of pressed parts **2a** makes contact with the electrode parts **4a**. The contact area of the conductive parts **2b** increases with the pressure force, changing the conducting resistance of electrode parts **23a**.

If the pressing onto the operating body **10** is released, the pressed parts **2a** of acting body **2** and the rod-like projections **2c** for shake prevention are restored to the original state by their own elasticity, respectively, and the downside of operating body **10** is supported by the rod-like projections **2c** again to prevent shaking.

Thus, in the above-mentioned variable resistor, the rod-like projections **2c** for shake prevention adjacent to the pressed parts **2a** and have a larger height dimension than the pressed parts **2a** are vertically provided upside of acting body **2** and their upper ends make contact with the pressing parts **12** of operating body **10**. Therefore, even when a plus-side error in height dimension of the rod-like projections **2c** for shake prevention is generated, the rod-like projections **2c** flex more or less, and improper press force is not applied to the pressing parts **12** in the non-pressed state, thereby obtaining anticipated resistance change in the variable resistor, making it possible to form a large height dimension of the rod-like projections **2c** for shaking prevention beforehand by considering a minus-side error portion, accurateliy bringing the upper ends of the rod-like projections **2c** into contact with the pressing parts **12** of operating body **10** to reliably prevent shaking of operating body **10**.

The case of applying the present design to the seesaw type variable resistor was shown in the above example. However, the present design may also be applied in other types of variable resistors with one, three or more pressed parts. Moreover, electrode parts using a resistance film were shown as the electrode parts **4a**, but electrode parts using a pressure-sensing conductive material the same as

in the prior example may also be used. Furthermore, the case of forming the projections for shake prevention in the shape of rod was shown, but various shapes of projections may be adopted if the projections are in contact with the pressing parts and may prevent the shaking.

(Efficacy of the design)

As described in detail above, according to the present design, the projections for shake prevention flex more or less and an improper press force is not applied to the pressing parts of the acting body in the non-pressed state, thereby obtaining anticipated resistance change in the variable resistor even if a plus-side error in the height dimension of projections is generated. Moreover, it becomes possible to form a large height dimension of projections beforehand by considering a minus-side error, therefore the upper ends of the projections may be accurately brought into contact with the pressing parts of operating body to reliably prevent shaking of the operating body.

4. Brief description of the drawings

Fig. 1 to Fig. 3 show an example of applying the present design to a seesaw type variable resistor Fig. 1 is the sectional view of the variable resistor, Fig. 2 is a top view of a resistor main body, Fig. 3 is the illustrative drawing of operations, and Fig. 4 is the sectional view of the prior variable resistor.

In the drawings,

1	resistor main body
2	acting body
2a	pressed body
2c	rod-like projection for shake prevention
4a	electrode part
10	operating body
12	pressing part

1 resistor main body

2 acting body

2a pressed body

2c rod-like projection for shake prevention

4a electrode part

10 operating body

12 pressing part

Sectional view of variable resistor

[Fig. 1]

Top view of resistor main body

[Fig. 2]

1 resistor main body

2 acting body

2a pressed body

2c rod-like projection for shake prevention

4a electrode part
10 operating body
12 pressing part

Illustrative drawing of operations

[Fig. 3]

20 resistor main body
21 acting body
21a pressed body
21a1 projection
23a electrode part
30 operating body
32 pressing part

Sectional view of prior variable resistor

[Fig. 4]

CERTIFICATE OF TRANSLATION

I Roger P. Lewis, whose address is 42 Bird Street North, Martinsburg WV 25405, declare and state the following:

I am well acquainted with the English and Japanese languages and have in the past translated numerous English/Japanese documents of legal and/or technical content.

I hereby certify that the Japanese translation of the attached translation of documents identified as:

Utility Model Application

H3-61304

"Variable Resistor"

is to the best of my knowledge and ability true and accurate.

I further declare that all statements contained herein of our own knowledge, are true, that all statements of information and belief are believed to be true.

ROGER P. LEWIS

October 24, 2006

The Rockin'Mouse: Integral 3D Manipulation on a Plane

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ABSTRACT

A novel input device called the Rockin'Mouse is described and evaluated. The Rockin'Mouse is a four degree-of-freedom input device that has the same shape as a regular mouse except that the bottom of the Rockin'Mouse is rounded so that it can be tilted. This tilting can be used to control two extra degrees of freedom, thus making it suitable for manipulation in 3D environments. Like the regular mouse, the Rockin'Mouse can sense planar position and perform all the usual functions. However, in a 3D scene a regular mouse can only operate on 2 dimensions at a time and therefore manipulation in 3D requires a way to switch between dimensions. With the Rockin'Mouse, however, all the dimensions can be simultaneously controlled. In this paper we describe our design rationale behind the Rockin'Mouse, and present an experiment which compares the Rockin'Mouse to the standard mouse in a typical 3D interaction task. Our results indicate that the Rockin'Mouse is 30% faster and is a promising device for both 2D and 3D interaction.

Keywords

3D interaction, input devices, integral motion, mouse, 3D graphical manipulators.

INTRODUCTION

The ever increasing speed of computers in recent years has led to the proliferation of tools for creating and manipulating 3D graphics. While the visuals produced by state-of-the-art 3D graphics systems are of very high quality, interaction techniques for manipulation within these systems often suffer from the limitations of currently available input devices.

These interaction techniques can be broadly classified into two categories: those based on three or more degree-of-freedom input devices [7, 11, 12, 16, 19, 21, 22], and those which rely on the ubiquitous mouse coupled with a variety of schemes for mapping 2D input to 3D control [3, 5, 6, 8, 15, 18]. At first glance, it would seem that the increased sense of directness usually afforded by the techniques in the first category would make multiple degree-of-freedom input devices the obvious choice for 3D applications. In reality, however, the mouse continues to be the dominant input device in the world of 3D graphics.

A key contributing factor to the mouse's preeminence is that most users of 3D graphics applications do not work exclusively in 3D; rather, in a typical scenario a user is likely to frequently switch between 2D and 3D applications. In addition, even 3D applications usually require a substantial amount of 2D interaction – manipulating 3D objects in 2D views as well as the usual 2D tasks of selecting items from menus, typing text, etc. While the mouse is indisputably a good device for 2D interaction, it performs only adequately in 3D tasks. Practically all existing 3D devices, however, perform poorly in 2D tasks when compared to the mouse. Therefore, it comes as no surprise that users pick the mouse as their all-purpose input device. They are clearly prepared to sacrifice peak 3D performance to avoid having to constantly switch between the mouse and a device better suited to 3D interaction. This leads us to the obvious conclusion that what is needed is an input device that performs reasonably well for *both* 2D and 3D tasks.

In this paper, we first explore the properties of the mouse that make it so successful. We then describe a new device, the Rockin'Mouse (Figure 1), which incorporates these properties while providing simultaneous control over four degrees of freedom. Finally, we present the results of an experiment to investigate the performance of the Rockin'Mouse vs. the mouse in a typical 3D interaction task.

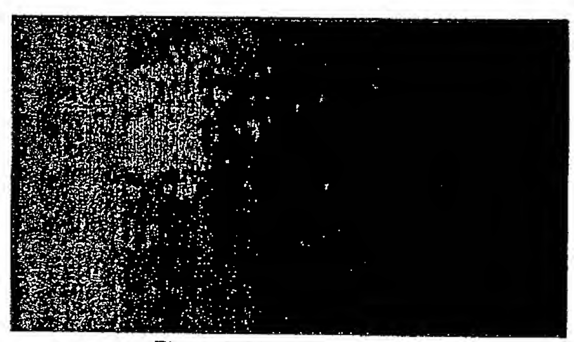

Figure 1. The Rockin'Mouse.

DESIGNING AN EFFECTIVE INPUT DEVICE

Designers of new input devices often evaluate them based on criteria such as task completion times for pointing to or manipulating on-screen widgets. While this style of evaluation is certainly valid, it is incomplete. There are a host of other properties and issues at play that determine whether or not a device will be successful and widely adopted.

What's So Great About the Mouse?

In trying to understand why the mouse has enjoyed quite a bit of success over the past two decades or so, we found that – apart from the convenience factor discussed in the introduction – it has many subtle redeeming properties that should be taken into account when designing a new input device:

Form Factor

The physical form of the mouse, coupled with the fact that it operates on a flat horizontal surface, ensures that the user is not restricted to any particular grip. The mouse can be used in a variety of ways – ranging from a precision grip for accurate movements, to "lazy" or "relaxed" grips when simply moving the cursor from one window to another. Also, the user's arm is generally resting on a table while moving the mouse. This is less fatiguing when compared to using 3D devices like the Bat [21], Polhemus 3Ball [16], and Logitech 3D/6D [12] mouse, all of which require the user's arm to be suspended in 3D space.

Stability

Since the mouse is fairly heavy and has a large area in contact with the surface it moves on, tremor in a user's hand is dampened, allowing for precision operation. In contrast, free-floating 3D devices [12, 16, 21] and stylus' on digitizing tablets [20] tend to transmit, and in some cases amplify, human hand tremor.

Also, the mouse is usually in a stable state where it is ready to be used and does not have to be "disturbed" to acquire or release the device. The position of stylus and 3D devices, however, will be disturbed when a user picks up the device up or puts it down.

Relative vs. Absolute Mode

Input devices can either report their absolute measured position or their current position relative to some key point (usually the point when the device was engaged). Because the mouse is a relative device with implicit clutching, the amount of arm movement required to effectively use it can be very small. Thus, the user need not expend much effort when working with the mouse. Further, relative devices do not suffer from the "nulling problem" [1] associated with absolute ones.

The implicit clutching mechanism – lifting the mouse off and replacing it on the work-surface to engage and disengage it – is easily understood and executed. It is also flexible and comfortable when compared to using an explicit clutch button like that found on other devices [12, 16, 21].

Order of Control

Zhai [23] has shown that for common 3D tasks such as object manipulation, position control input devices are superior to rate control devices. In the 2D world, position control is critical for pointing tasks. It also allows for reversible actions: for example, a designer using a position control device to manipulate the camera view in a 3D modeling application can "spin the world around" to get a quick look of the model from a different viewpoint and then return to the original view and continue working, all within a split second. This type of action, performed many times a day by users of such applications, is practically impossible with force sensing rate control devices like the Magellan [11].

We note that some tasks such as navigation in large scenes are more suited to rate control. However, the mouse can easily be used as a rate control device by employing a first order transfer function. The converse is not true: force sensing devices cannot operate in position control mode.

Device to Cursor Mapping

The default mapping of mouse motion to cursor motion is "natural" (i.e., moving the mouse forward moves the cursor up, moving the mouse left moves the cursor left, etc.). This reduces the cognitive load imposed on the user since the mapping is simple. Most position control 3D devices [12, 16, 21] have this feature, while force sensing devices [11] often use more complicated device to cursor mappings.

Button Position

The direction of movement of the mouse buttons are orthogonal to the sensing dimensions of the mouse. Thus, it is easy to operate the buttons without inadvertently moving the cursor. This is one reason why "3D mice" which use a thumbwheel to control the third degree of freedom [19] have not been very successful.

Familiarity

Our final point has to do with the nature of human beings. We humans like to deal with things we're familiar with, and we are extremely familiar with the form and function of the mouse. Indeed, an entire generation has grown up using it. We believe that a device that radically differs from the mouse will have to deliver correspondingly high performance improvements in order to gain widespread acceptance. Unfortunately, given our high level of skill with the mouse, it is unlikely that any new device could facilitate performance improvements of the required magnitude. Instead, an incremental change in design leading to an evolution in the quality of interaction will likely result in a more successful input device.

Where the Mouse Falls

The factors described above make the mouse an almost perfect 2D input device. While these factors are equally critical in 3D interaction, the mouse does not inherently support 3D operations. Over the years, several mechanisms have been developed to enable 3D manipulation using only the two degrees of freedom provided by the mouse.

The simplest method, from a systems standpoint, is to use modifier keys (sometimes called hot-keys) or the mouse buttons to switch between movement in the three axes. This scheme, while adequate, is rather unnatural. First, the user has to remember which key selects a particular axis of movement, and second, in what direction to move the

mouse to accomplish the desired movement.

More effective schemes which exploit the visual channel have been proposed by researchers [3, 5, 6, 8, 15, 18] and are currently implemented in several commercially available applications. The key idea here is that the 2D mouse cursor is used to select a virtual "manipulator" (also called "handle", "controller", or "3D widget") associated with a particular transformation. For example, to effect translational motion along the x-axis[1], one would select the x-axis translational manipulator for the desired object and drag it to the required location. Obviously, since the mouse provides only two degrees of freedom, the manipulators generally allow only transformations along two dimensions at a time (there are exceptions to this rule: uniform scaling along three dimensions is an example).

The problem with these schemes is that they often reduce a task that would *ideally* be performed in a single integral movement into two or more sub-tasks. For instance, using virtual translational manipulators to move an object in 3D space requires at least two motions: one motion along the x-y plane followed by another motion along the x-z plane. While the user can still perform the task, the interaction technique differs from the user's experience with the physical world, thus incurring an additional cognitive cost. This problem is even more acute when the task absolutely requires simultaneous manipulation of all three dimensions: for example, specifying a 3D motion path of an object in real time – a task commonly performed in 3D animation software.

Buxton [1], Card et al. [4], and Jacob et al. [9, 10] have all emphasized the need for input devices to match the user's high-level conceptual model of the task. Indeed, Jacob et al. [9, 10] have shown that tasks in which the conceptual model of manipulation integrates all dimensions benefit from input devices which also support this integration. They also point out the opposite: that multiple degree-of-freedom tasks where the dimensions are conceptually independent (e.g., adjusting object position and color) do not benefit from input devices which integrate all dimensions.

1. We use the following convention for labelling 3D axes in this document: "x" is the left-right axis, "y" is the up-down axis, and "z" is the near-far axis.

THE ROCKIN'MOUSE

The Rockin'Mouse (Figure 1) is a new input device designed to retain the characteristics of the mouse which make it so successful while overcoming it's main shortfall by providing a seamless shift into integral 3D manipulation when desired.

Like a regular mouse, the Rockin'Mouse senses it's position on the surface of operation. In addition, a novel curved base design allows the mouse to be tilted about the x and z axes (Figure 2). The amount of tilt is sensed and can control two extra degrees of freedom.

While the base can be curved in a variety of ways, our preferred implementation uses an asymmetric curvature about the two axes. The curvature about the z-axis is greater than that about the x-axis, resulting in a similar footprint to the regular mouse. The Rockin'Mouse has a flat spot at the centre of the curved base to make it self-righting and improve stability. An interesting artifact of this flat spot is that it allows the device to be physically constrained to control only two degrees of freedom even while sensing four. This is often desirable when manipulating 3D objects.

The Rockin'Mouse, like the mouse, is a relative device where clutching is accomplished by lifting the mouse off and replacing it on the work-surface.

Prototype Implementation

Our prototype implementation (Figures 1 & 2) operates on a Wacom digitizing tablet [20]. This tablet is able to sense the position of a cordless sensor on the x-z plane of tablet and also the degree of tilt of the sensor about the x and z axes.

One of these cordless sensors is mounted in the center of the Rockin'Mouse, enabling the device's planar and angular position to be sensed when placed on the tablet. The current resolution of the tilt sensor is approximately one unit per degree. While this is insufficient for regular use, it suffices for evaluating our design. The tablet can also sense the state of Rockin'Mouse buttons connected to the sensor.

The mechanism that enables implicit clutching consists of a

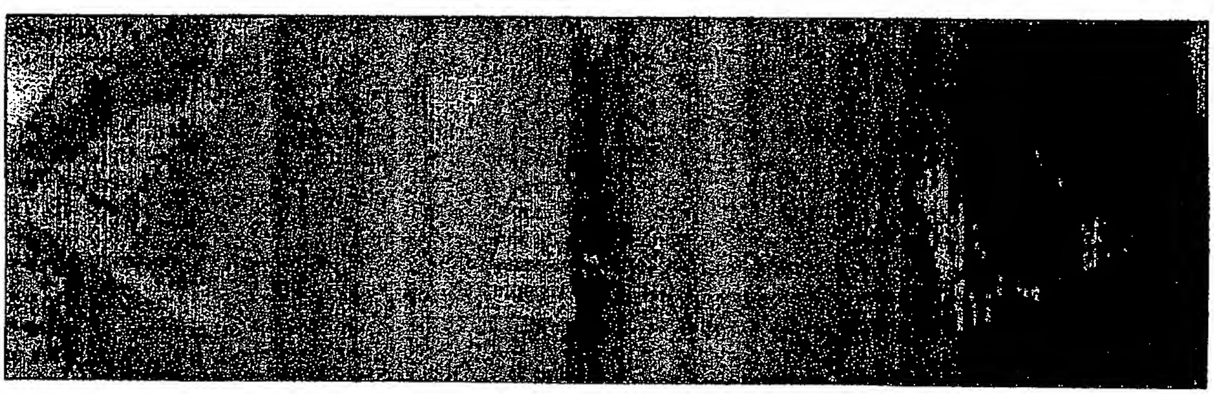

Figure 2. Tilting action of the Rockin'Mouse

contact switch between the curved base and the upper body of the mouse. The curved base is not tightly screwed to the upper body, instead 1 mm of vertical "play" enables the contact switch to open and close.

Application

It is our belief that although the tilting action of the Rockin'Mouse is not symmetric to the planar movements, simultaneous control of multiple degrees of freedom is possible if appropriate interaction techniques are used. This is what distinguishes the Rockin'Mouse from other mice variants [13, 19] which do not enable integral action of all sensed degrees of freedom. The ability to simultaneously control all dimensions of an integral task should result in performance improvements over the traditional mouse and manipulators. This advantage could be utilized in numerous applications.

In order to investigate these beliefs, we conducted an experiment:

EXPERIMENT

Method

Goal

The primary goal of the experiment was to evaluate the effectiveness of the Rockin'Mouse compared to the mouse in the context of a 3D object positioning task. We were particularly interested in whether or not subjects would be able to control movement in all three dimensions simultaneously using the Rockin'Mouse and if this translated to an improvement in task performance time. We were also interested in determining the learning effects associated with the Rockin'Mouse.

Apparatus

The experiment was conducted on a Silicon Graphics Indigo2 Extreme workstation with a 19 inch colour display and standard mechanical mouse. The Rockin'Mouse operated on a 12x12 inch Wacom digitizing tablet [20] attached to the workstation via a 19200 bps serial connection. The workstation ran in single-user mode, disconnected from all network traffic. A graphics update rate of 30 hz was maintained. Subjects were seated approximately 60 cm in front of the display with their right hand manipulating the mouse or Rockin'Mouse on the digitizing tablet placed to the right of the display (Figure 3).

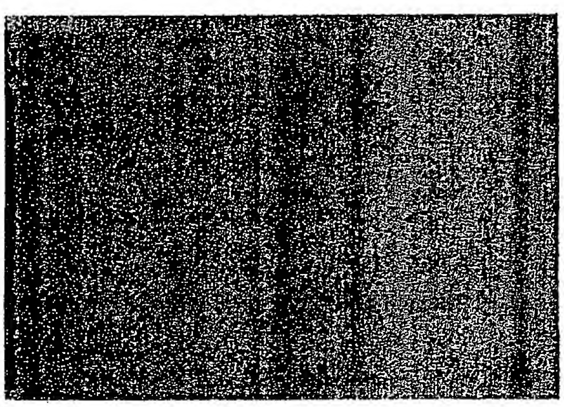

Figure 3. Experimental set-up

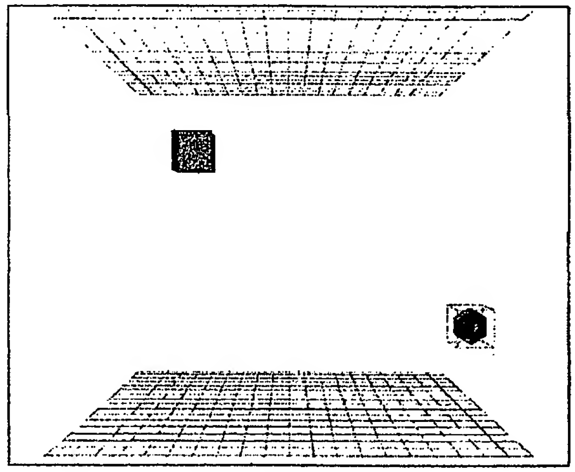

Figure 4. Visual Stimuli

Task and Stimuli

The 3D object positioning task required subjects to move an object from one corner of the virtual 3D scene and place it inside another object located at the diagonally opposite corner.

As illustrated in Figure 4, the lit scene consisted of two light grey wireframe grids drawn in the horizontal plane at the top and bottom of the screen. The purpose of these grids was to enhance the perception of depth in our perspective display. The object to be manipulated was a gold coloured sphere surrounded by a wireframe bounding box. The target object was a purple cube with translucent faces. Colours and transparency effects were chosen to ensure that subjects were not hindered in their task by insufficient visual cues. The manipulated object was two thirds the size of the target.

In the mouse conditions, subjects used the left mouse button to select one of three translational manipulators. Clicking on the front face of the object's bounding box selected the x-y manipulator while the y-z and x-z manipulators were selected by clicking on the left/right and top/bottom faces respectively. Holding the left button down and moving the mouse effected 2D movement of the object in the active manipulator's plane. Therefore, a single 3D movement required subjects to switch between at least two manipulators.

In the Rockin'Mouse condition, pressing the left button selected the entire object. Moving the Rockin'Mouse left-right and forward-backward on the tablet caused the object to move in the x-direction and z-direction respectively. Tilting the Rockin'Mouse clockwise-anticlockwise moved the object up-down in the y-direction. Linear control-display mappings were used for both devices.

In both conditions, the target turned bright green when the object was within its boundaries. Subjects released the left button while the object was within the target to indicate completion of a trial.

Subjects

Fourteen volunteers (13 male, 1 female) served as subjects in this experiment. All were right handed. Three regularly used the mouse with graphical manipulators in 3D scenes, while the remaining eleven were familiar with 2D use of the mouse but had limited experience with 3D environments.

Design and Procedure

A balanced within-subjects repeated measures design was used. Each subject was tested with both devices on the same day. For each of the devices, subjects were given six blocks of trials. Each block consisted of eight conditions: we tested subject's ability to move an object from each of the eight corners of the viewing volume to a target located at the diagonally opposite corner. For reasons that will be elaborated on shortly, subjects performed four trials in a row for each condition. All eight "direction of movement" conditions were presented in random order during the block. The experiment consisted of 5376 trials in total, computed as follows:

14 subjects x
2 devices per subject x
6 blocks per device x
8 conditions per block x
4 trials per condition
= 5376 total trials.

Prior to performing the experiment with each device, subjects were shown how to operate the device and were given practice trials for each condition. Practice lasted about fifteen minutes. For each device, subjects took between thirty and forty-five minutes to perform all the trials. They were allowed to take short breaks between each condition, but were required to complete all four trials within a condition without breaks. Timing began when the object appeared on screen and ended when it had successfully been placed inside the target. There was a 800 ms pause before the next trial began. Subjects were alternately assigned to one of two experimental orders: Rockin'Mouse first (R/M) or mouse first (M/R).

A short questionnaire designed to elicit subjective opinions of the two devices and associated interaction technique was administered at the end of the experiment.

Pilot Results

An analysis of data from pilot tests showed that the task was divided into two phases: an initial open-loop or ballistic phase which gets the object in the vicinity of the target, followed by one or more closed-loop movements which precisely positions the object within the target. With the mouse, the ballistic phase is usually performed with two 2D movements. With the Rockin'Mouse, the ballistic phase can be accomplished with a single 3D movement. However, we believe that the cognitive load imposed on the subject when planning the more complex 3D gesture is higher than for the mouse's simpler 2D movement. In other words, the "chunk" [2] of the problem being solved is larger. Our hypothesis is that subjects will eventually be able to perform this planning automatically, however, much learning through repetition is likely required [14].

Although we were interested in determining subjects' performance before and after this learning occurred, the experiment was too short to allow subjects to reach expert levels of performance. Therefore, we designed a compromise solution: for each of the eight conditions, subjects performed four trials in a row. For each trial, the target appeared at a slightly different position in the vicinity of the pertinent corner for that condition. This essentially prevented subjects from memorizing the exact location of the target from trial to trial, ensuring that the non-ballistic portion of the task always required closed-loop control. For the initial ballistic phase, however, most of the planning would likely occur during the first trial. Since the last three trials require the same ballistic movement, subjects would not have to plan the movement again. Thus, performance in the last three trials would closely approximate how subjects would perform after substantial learning.

Results and Discussion

Task Completion Time

Figure 5 compares subjects' mean trial completion times with both devices for each of the six blocks. A repeated measures analysis of variance with trial completion time as the dependent variable showed the Rockin'Mouse performing significantly better than the mouse ($F_{1,12} = 21.08$, $p < .001$). Overall, despite the limited tilt resolution, subjects were able to complete the task 30% faster with the Rockin'Mouse.

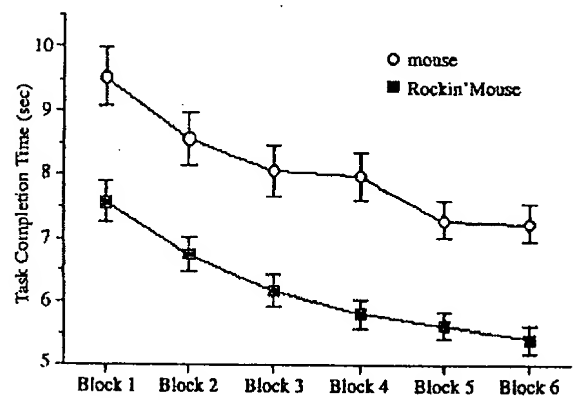

Figure 5. Mean task completion time for both devices over the course of six experimental blocks. Data from all 14 subjects. With 95% confidence error bars.

The order of presentation (R/M or M/R) had no significant effect ($F_{1,12} < 0.1$, $p > .5$) on the performance differences between the two devices. This, coupled with the absence of any Device x Order interaction ($F_{1,12} < 0.5$, $p > .5$), effectively ruled out the possibility of asymmetrical skill transfer – an oft overlooked artifact of within-subjects designs [17].

Direction of movement also had no effect on the performance differences between the devices ($F_{7,84} = 1.75$, $p > .1$). Apart from the learning effects discussed below, no other significant interactions were observed.

Learning

As apparent from Figure 5, subjects' performance with both devices improved over the course of the experimental blocks ($F_{5,60} = 23.01$, $p < .0001$). Also, the performance differences between the two devices were independent of block, as shown by the lack of a significant Device x Block interaction ($F_{5,60} < 1, p > .5$).

In addition to learning across blocks, there was also significant learning occurring over the four repeated trials within each condition ($F_{3,36} = 52.28$, $p < .0001$). A significant Device x Trial interaction ($F_{3,36} = 13.69$, $p < .0001$) was also apparent. As anticipated during the design of the experiment, the task completion time for the Rockin'Mouse in the first trial of each condition, while still faster than the mouse, is much slower when compared to the subsequent three trials (Figure 6). The performance of the mouse, however, does not significantly change over the four trials – evidence that the cognitive requirements of the ballistic phase of the task are spread throughout the several required 2D sub-movements.

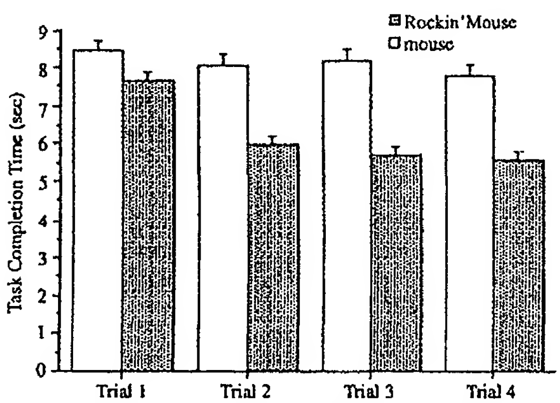

Figure 6. Mean task completion time for both devices over the four trials within each condition. Data from all conditions, blocks and subjects. With 95% confidence error bars.

The results show that when faced with a completely new movement condition, subjects required an average of about 1.5 seconds to plan the ballistic gesture for the Rockin'Mouse. If this planning is preprocessed, as in the last three trials per condition, subjects were 40% faster with the Rockin'Mouse. Of obvious interest, therefore, is the validity of our hypothesis that the cognitive cost of planning is reduced with practice.

In order to further explore this premise, we examined the performance difference between the two devices for only the first trial of each condition over the course of the six experimental blocks (Figure 7). As expected, the difference between the two devices increases as subjects get more skilled at the task, reaching statistical significance ($p < .05$) after block five. While more data is clearly needed to conclusively verify our hypothesis, this trend is a good indication that we are on the right track.

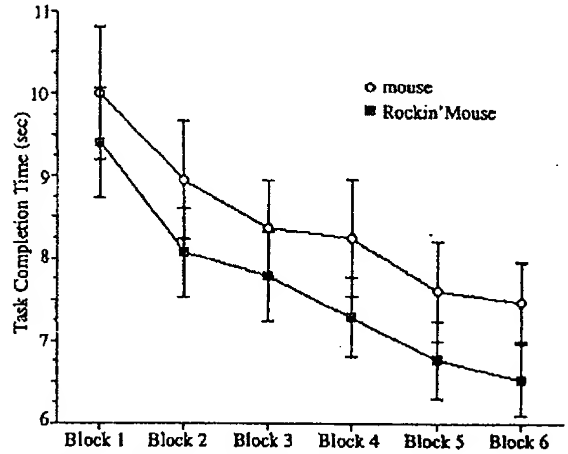

Figure 7. Mean task completion time for both devices for trial 1 within all conditions. Data from all 14 subjects. With 95% confidence error bars.

We also note that three of our subjects had substantial previous experience using the mouse with manipulators. Data collected from these subjects are probably skewing our results in favour of the mouse. However, since the Rockin'Mouse outperforms the mouse despite this bias, we decided not to present separate analyses for the expert and novice subjects.

Integration

As mentioned earlier, one aim of this experiment was to see if subjects could perform tilting and planar movements of the Rockin'Mouse concurrently, thus enabling integral 3D manipulation. We adopted a technique described by Jacob et al. [10] to quantify the level of integration achieved with the Rockin'Mouse. Essentially, the trajectory of the object during each trial was divided into small segments, each representing a 10 ms time interval. For each segment we determined if the object had moved during that time interval (a 0.1 mm position change in any axis was considered movement). The segment was then classified as *Euclidean*[2] if movement occurred in all three dimensions, or *city-block* if movement was only in one or two dimensions.

For the selected movement threshold of 0.1 mm within each 10 ms time interval, across all subjects, 49% of all movements with the Rockin'Mouse were classified as *Euclidean.* Also, approximately 70% of the *Euclidean* movements occurred during the first half of the trial – that is, primarily during the ballistic phase of the task. This is not surprising since during the final closed-loop phase of the task, subjects are fine-tuning the position of the object, usually one dimension at a time.

2. Terminology adopted from Jacob et al. [10]. *Euclidean* means movement cuts diagonally across the dimensions. *City-block* means movement resembles a staircase pattern akin to finding your way around buildings in a city.

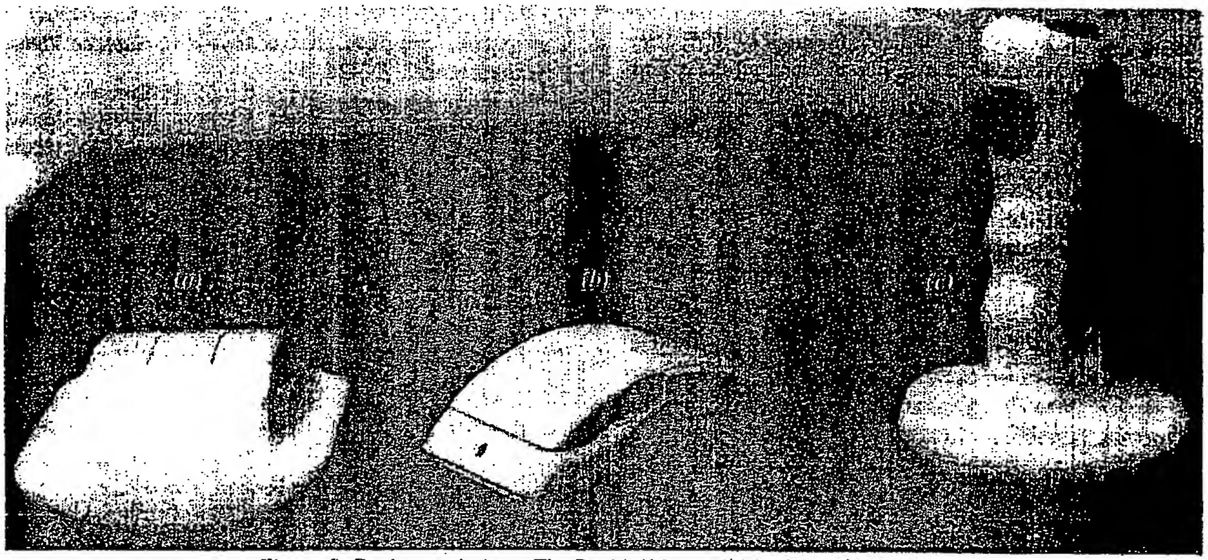

Figure 8. Design variations. The Rockin'Mouse (b) is shown for comparison.

These results clearly indicate that, where appropriate, subjects were able to control three dimensions simultaneously with the Rockin'Mouse. It is noteworthy that this level of integration was achieved despite limited practice.

Subjective Evaluation

Upon completion of the experimental trials, subjects filled out a questionnaire. Eleven of the fourteen subjects preferred the Rockin'Mouse to the mouse for the given task. Interestingly, two of the subjects who preferred the Rockin'Mouse were expert manipulator users. Finally, all the subjects said they felt they were able to control all three dimensions simultaneously with the Rockin'Mouse.

FUTURE DIRECTIONS

The results of our experiment indicate that the Rockin'Mouse is a promising device for integral 3D interaction. However, more work is clearly required to gain a better understanding of the capabilities, and limitations, of the device. In particular, we are interested in the long term learning effects: will users be able to significantly reduce the cognitive cost of planning the Rockin'Mouse's gesture? We also intend to explore different control-display mappings; for instance, first or second order control-display mappings may be appropriate for tasks such as navigating in 3D scenes.

In our experiment, left-right and forward-backward movements of the Rockin'Mouse controlled the object's movement in the x and z directions respectively, while clockwise-anticlockwise tilt controlled object movement in the y-direction. We felt that this was an intuitive mapping since it exploits the 1-1 mapping of device movement to object movement in two (x, z) of the three axes; however, alternative mappings clearly merit further investigation.

Aside from the new interaction techniques that will inevitably need to be developed for the Rockin'Mouse to be used in other interaction tasks using the dominant hand, use of the device in the non-dominant hand also merits investigation. For example, virtual camera control [22] could be performed using the non-dominant hand while the user interacts with objects in the scene with the dominant hand.

Despite our belief that close compatibility with the mouse is requisite for any device hoping to attain widespread use, we are nonetheless exploring alternative designs – two of which are shown in Figure 8. The base of the device in Figure 8(a) is curved about only one axis, allowing just a single dimension of tilt to be sensed. Since the area in contact with the working surface is larger than in the Rockin'Mouse, this device may afford greater stability. The device in Figure 8(c) has a base that is curved symmetrically about two axes, with a joystick-style grip. This device allows for a greater range of tilt and its form-factor may be ideal for entertainment applications. By investigating these variations we hope to gain deeper insights into the perceptual issues involved in interacting with this class of input devices.

CONCLUSIONS

Our experiment has shown that the Rockin'Mouse has the potential of providing at least a 30% performance gain over the regular mouse for 3D positioning tasks. We believe that for intensive 3D users, like professional 3D modelers and animators, this is a significant gain. It is also very encouraging that the Rockin'Mouse was preferred by the majority of our subjects (especially the expert mouse/manipulator users).

The results also indicate that subjects were able to simultaneously control all three dimensions. While this is clearly an acquired skill, the learning curve is acceptable. Finally, these positive results coupled with the fact that the Rockin'Mouse is backwardly compatible with the mouse make it potentially a very practical 3D input device.

ACKNOWLEDGMENTS

We thank Bill Buxton for valuable discussions during the course of this work. We'd also like to thank all the volunteers who participated in our experiment. We are grateful to Wacom Technology Corporation for generously providing the cordless tilt-position sensors that enabled us to prototype our design.

Alias|Wavefront Inc. is seeking trademark and patent protection for the Rockin'Mouse.

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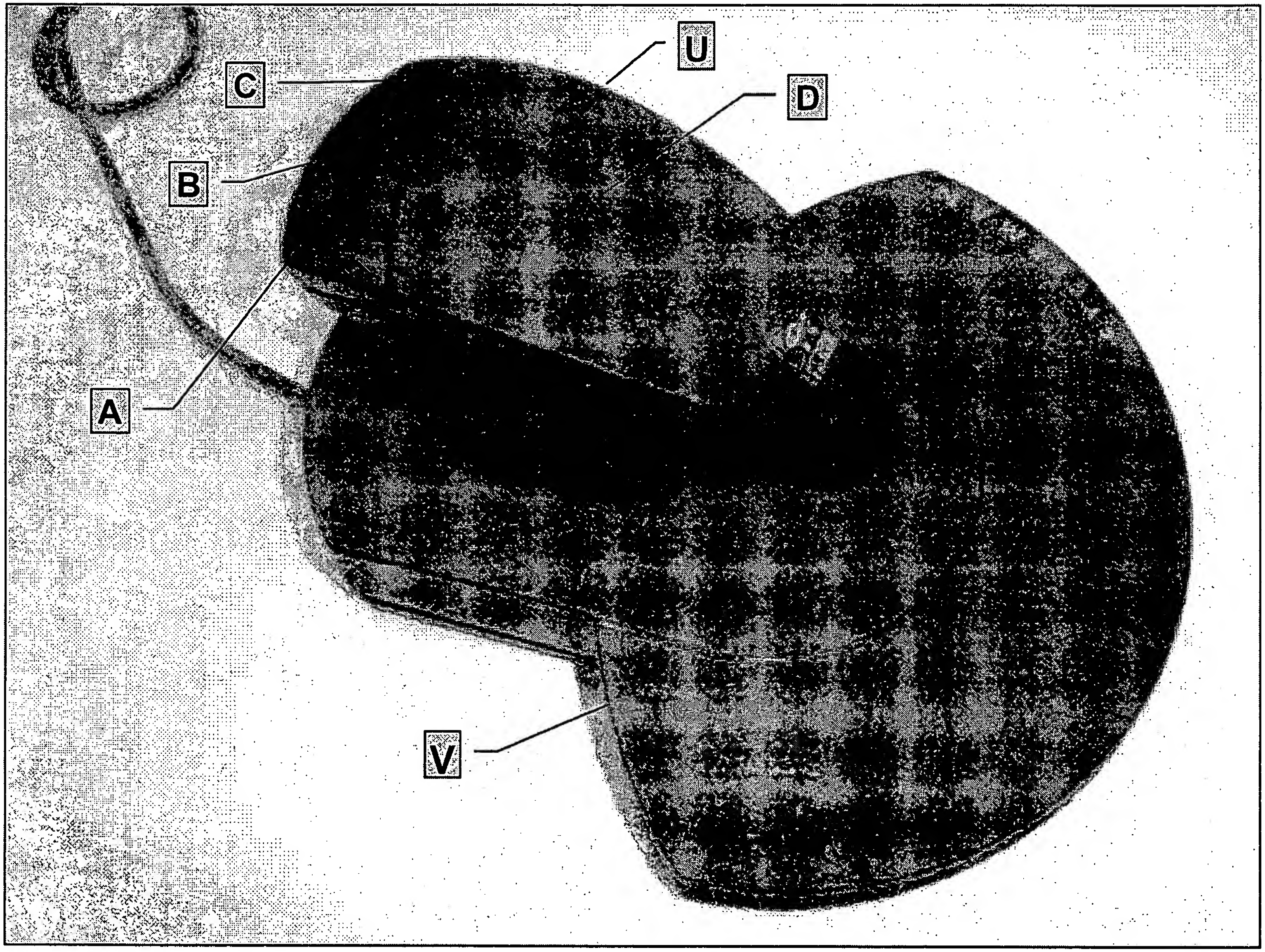
Cyberman Controller



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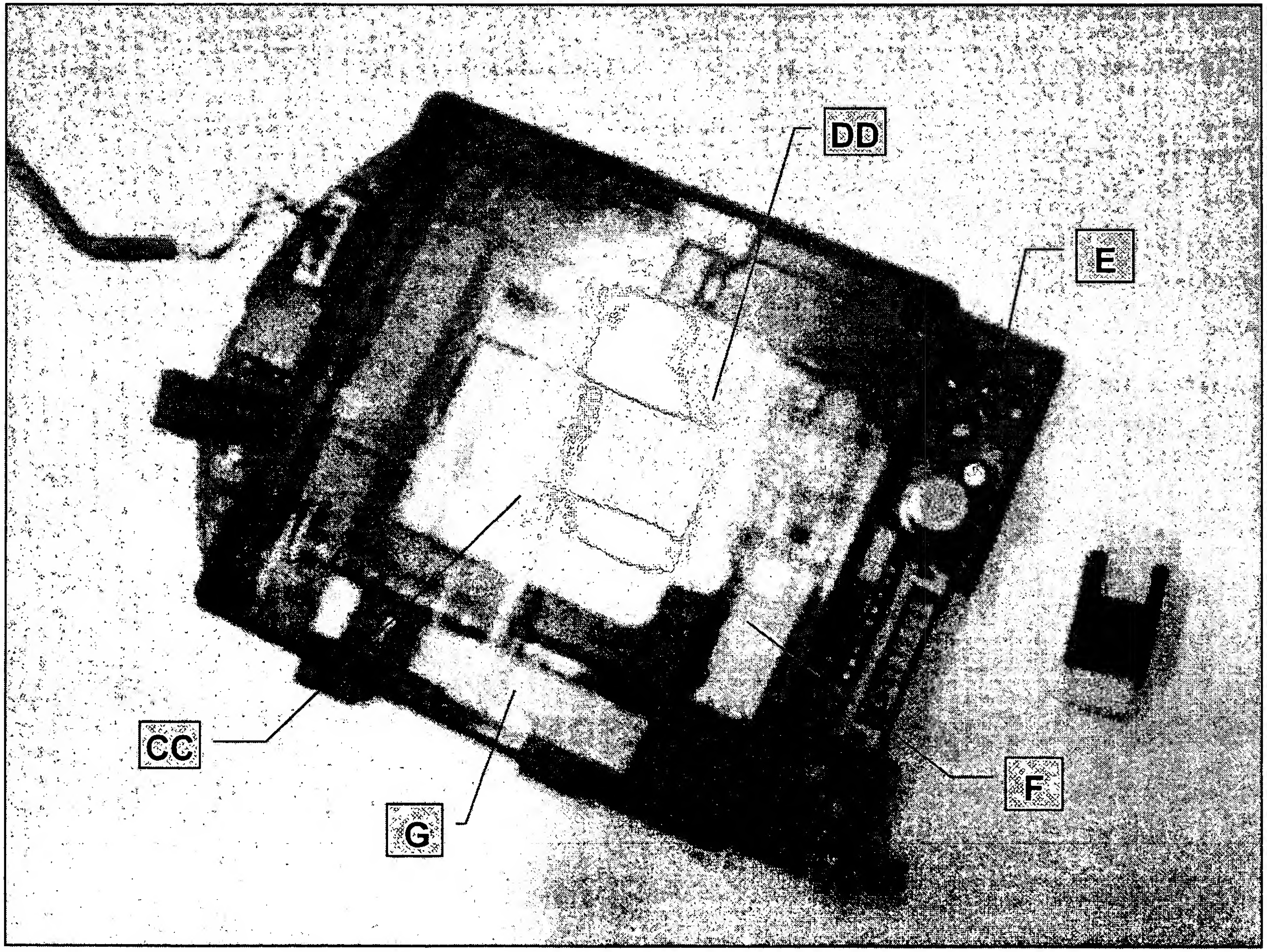

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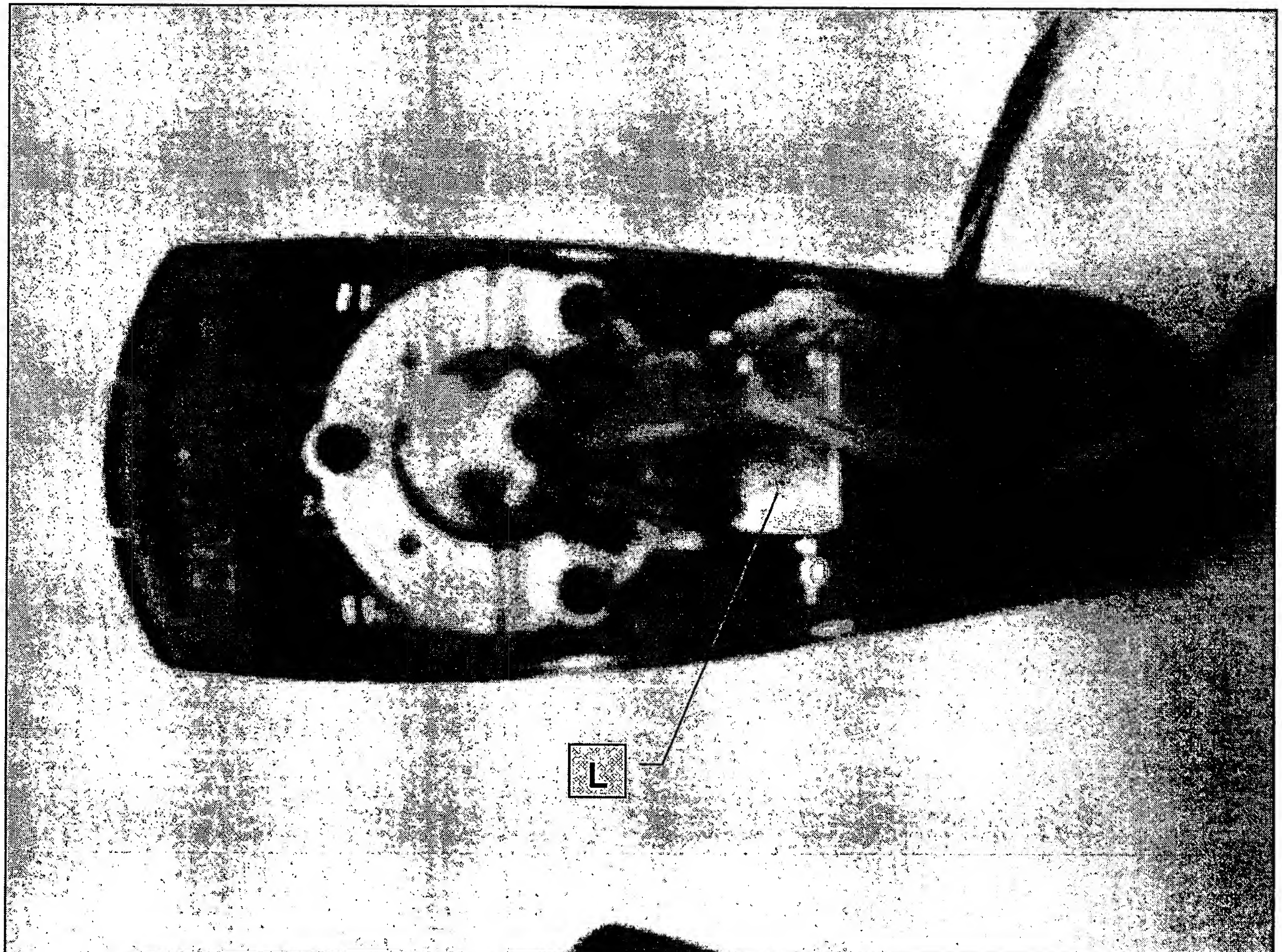

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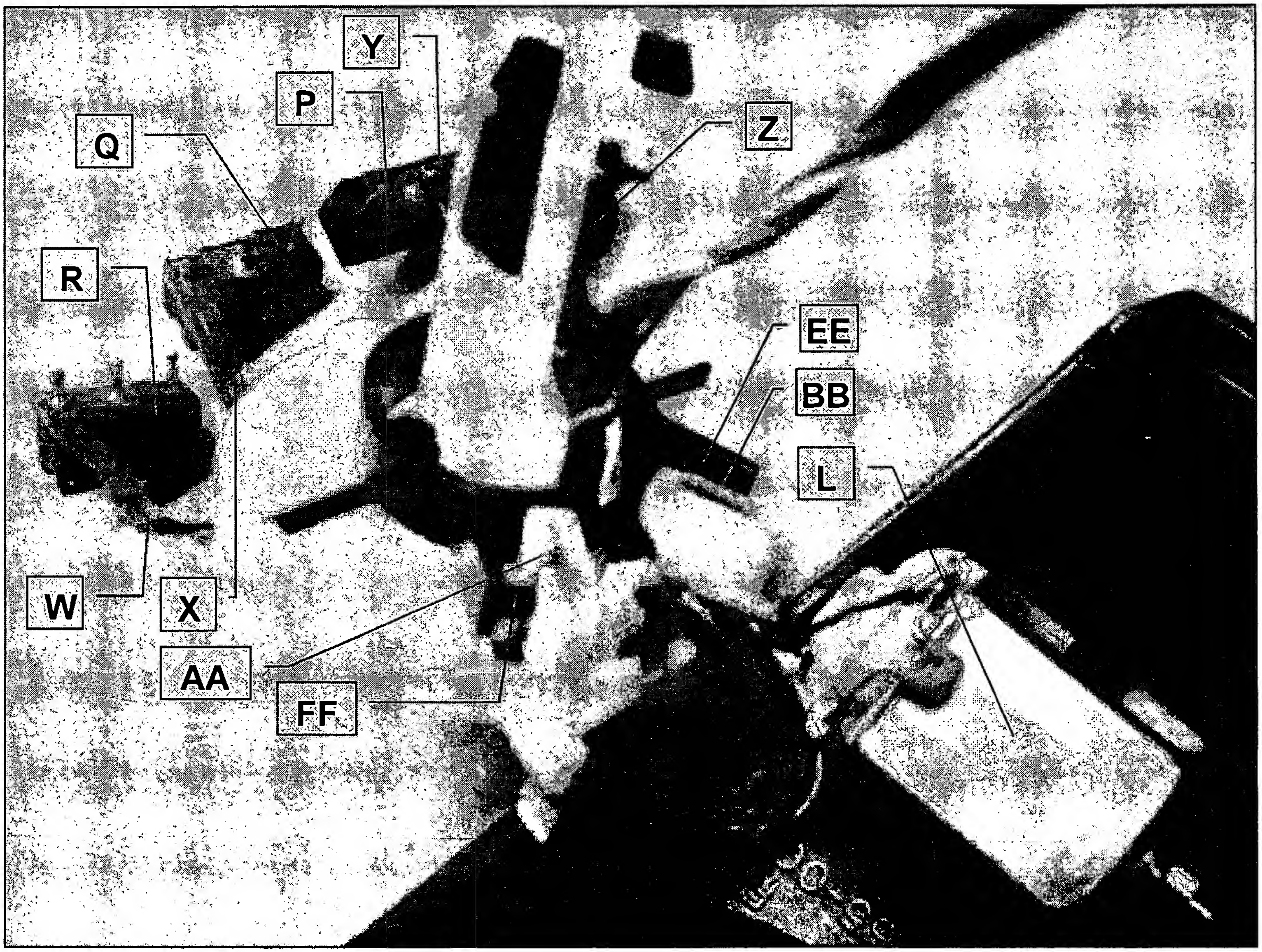

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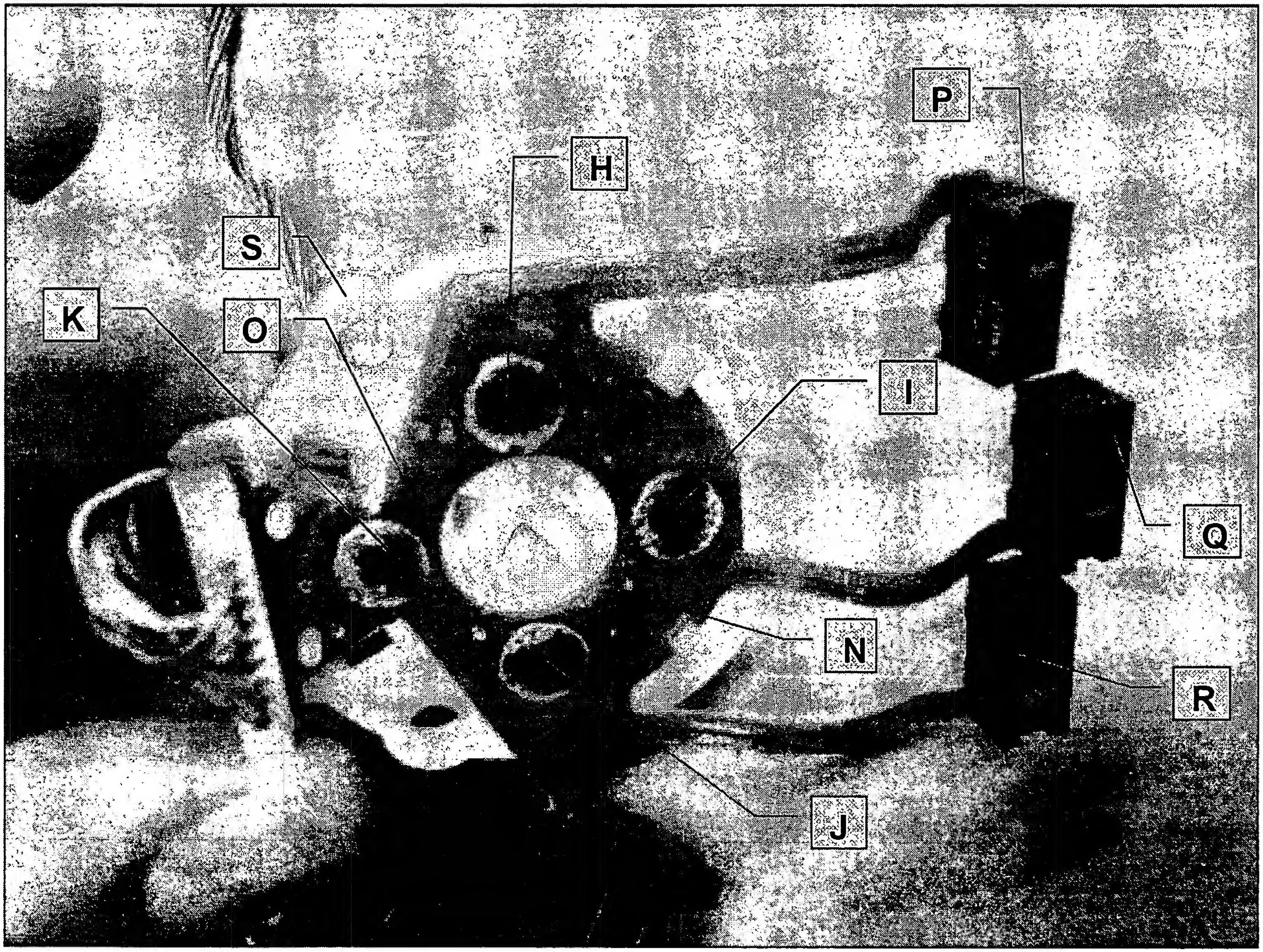

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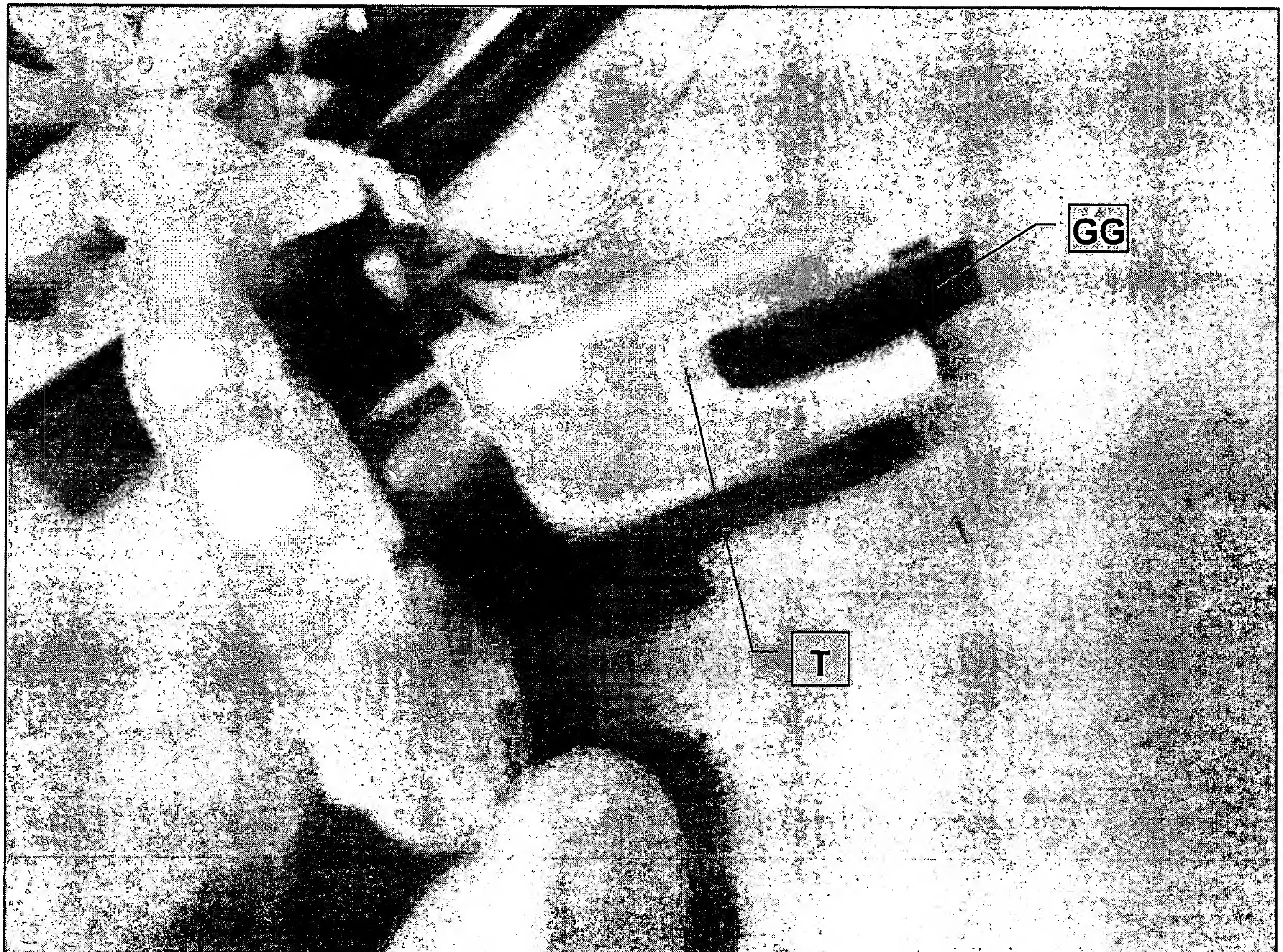

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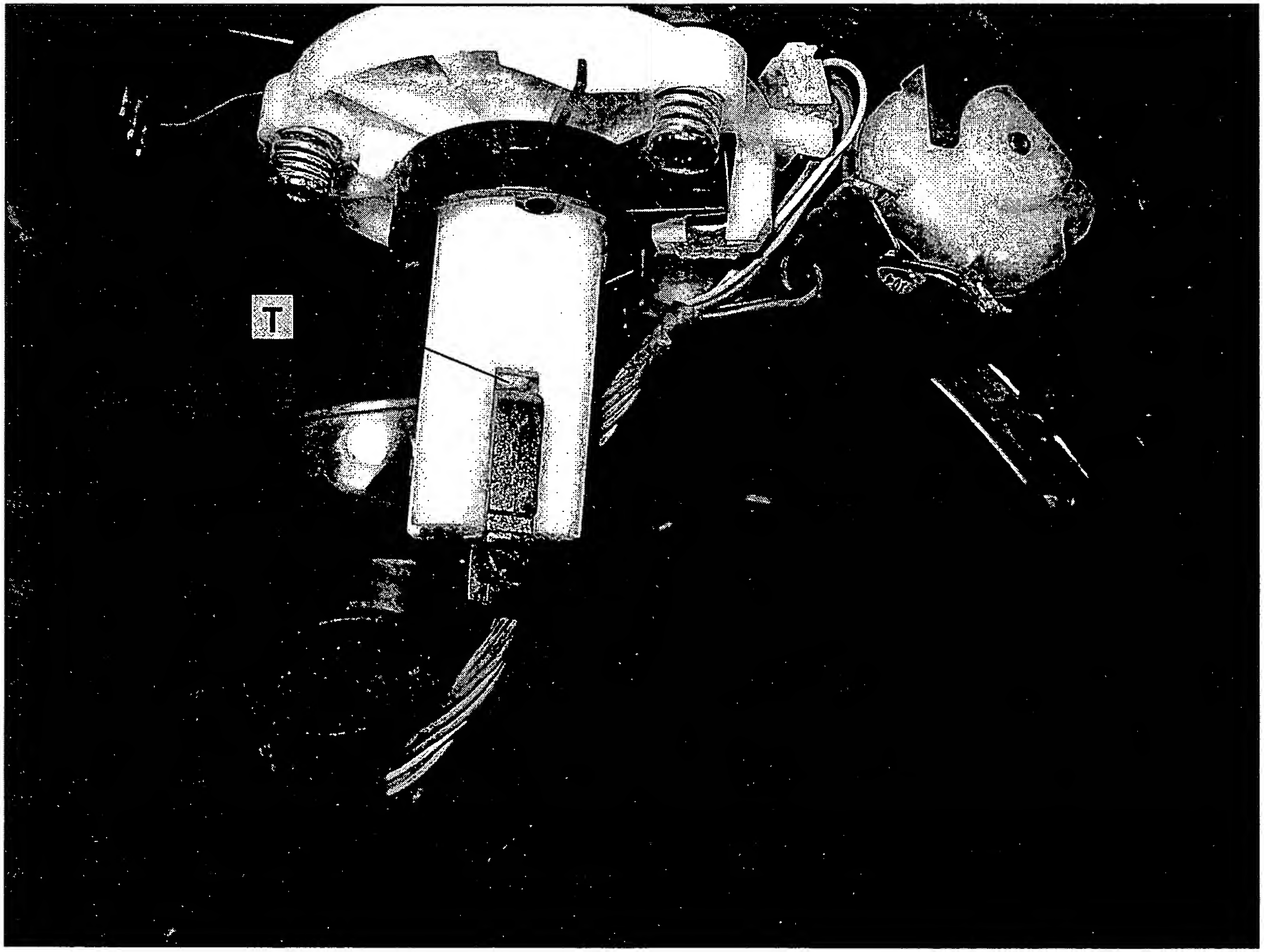

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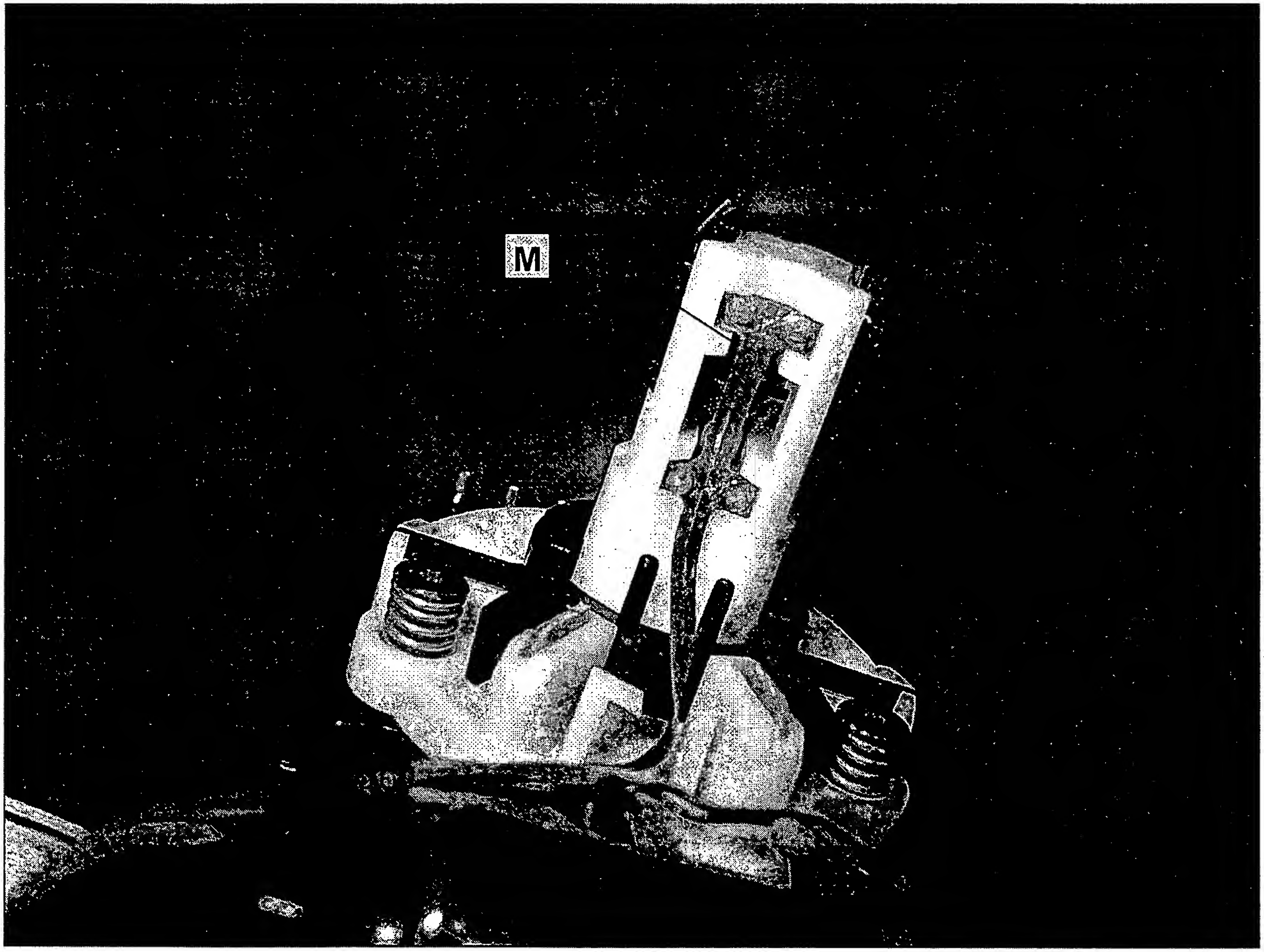
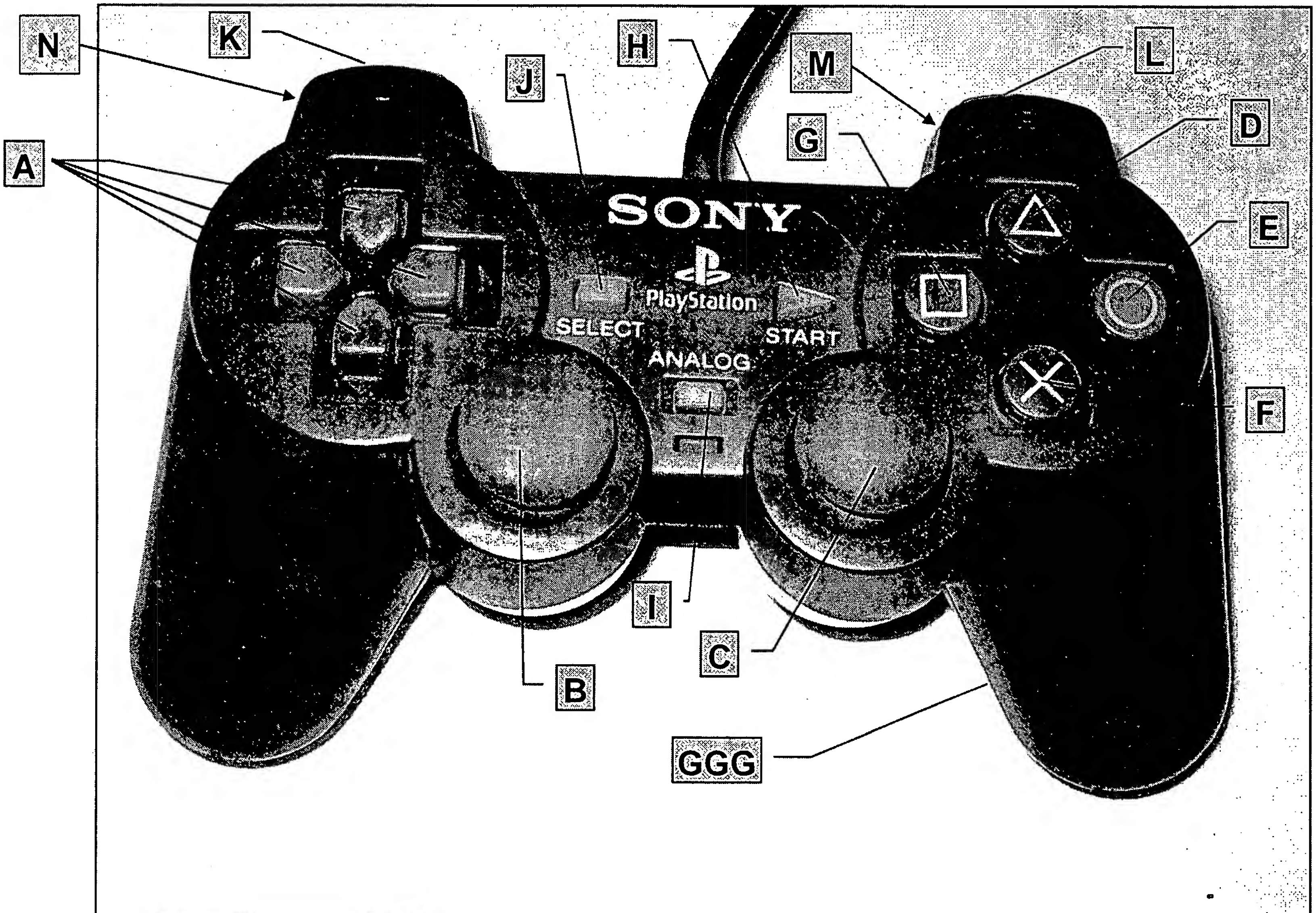


Sony Dual Shock 2 Controller



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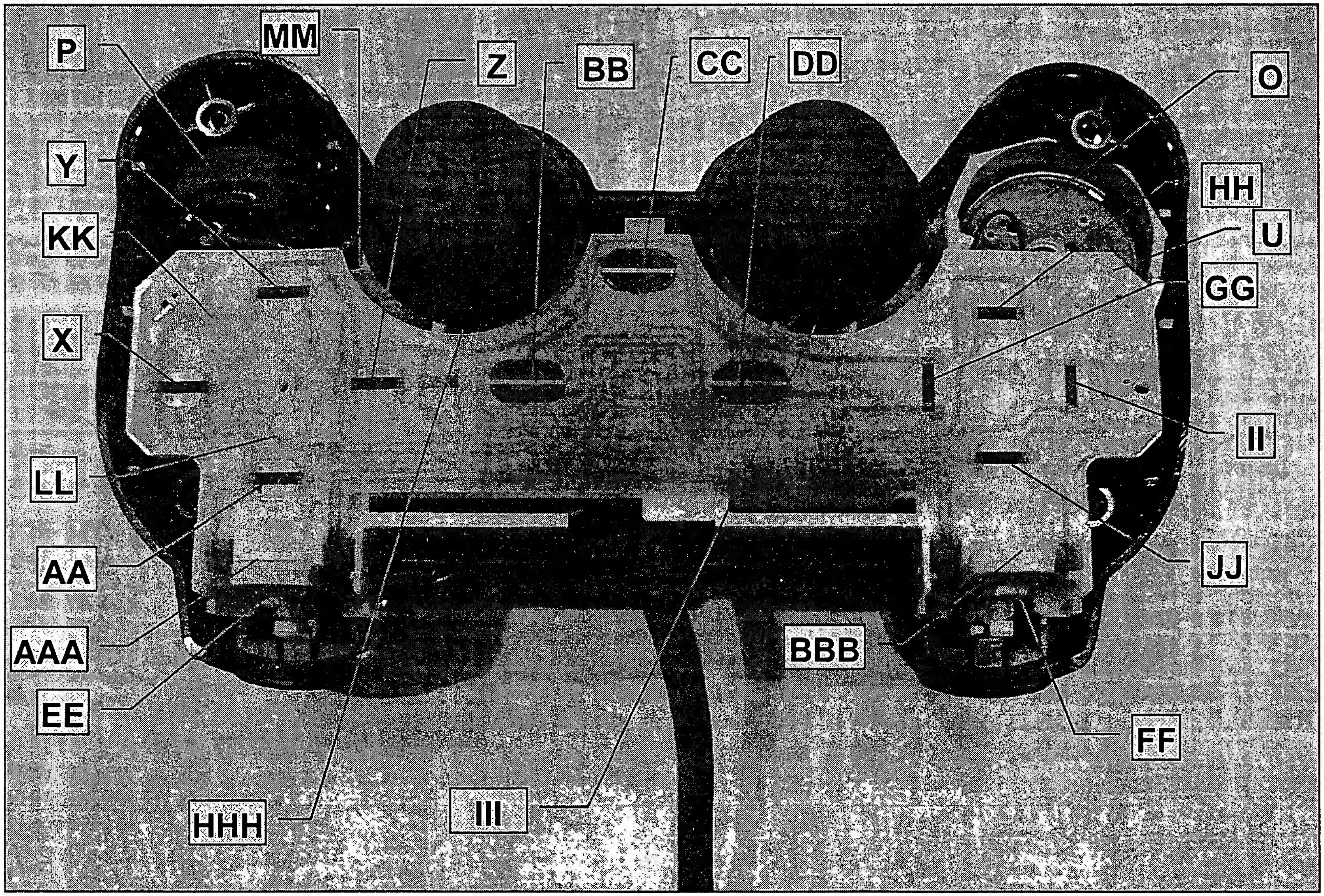

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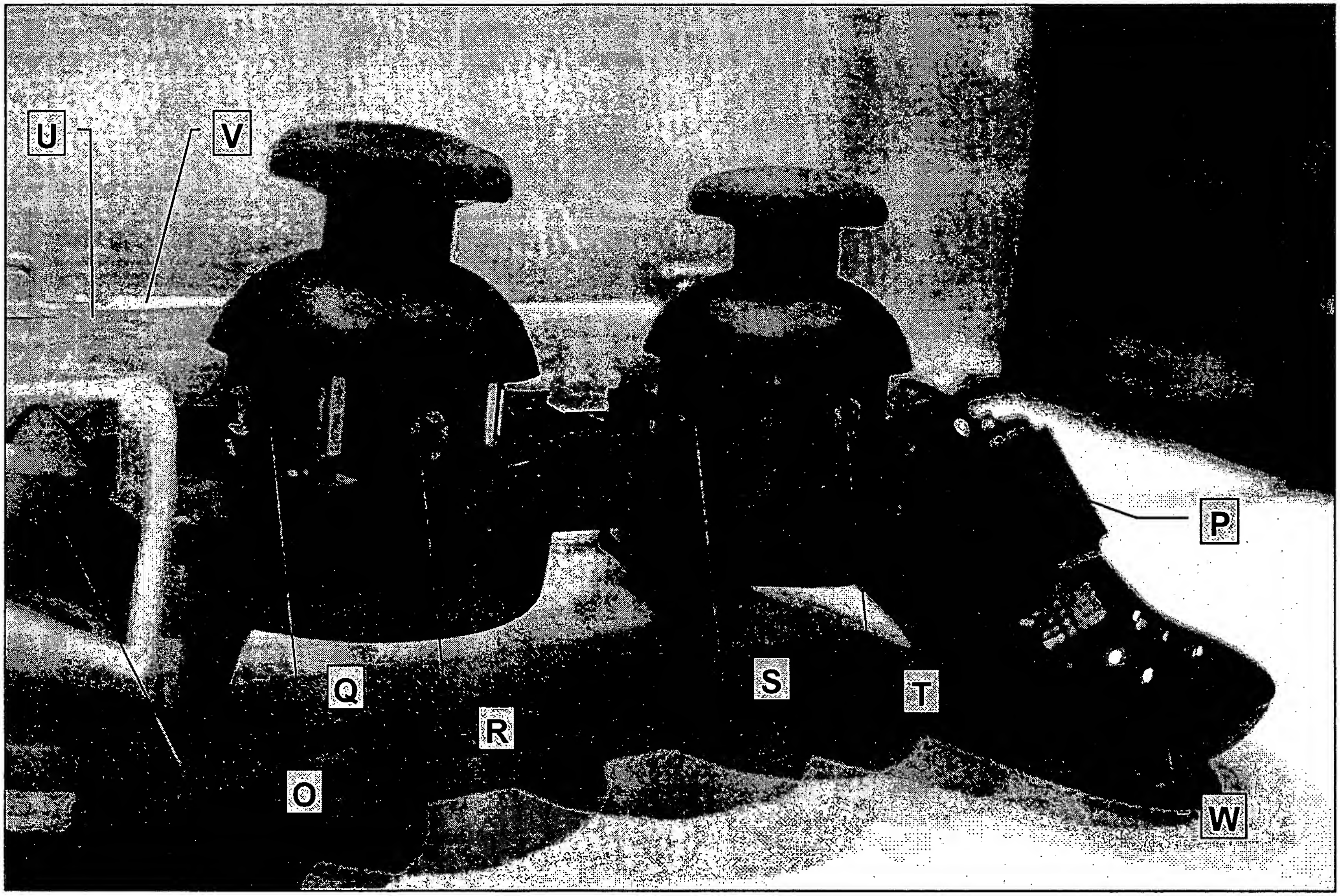

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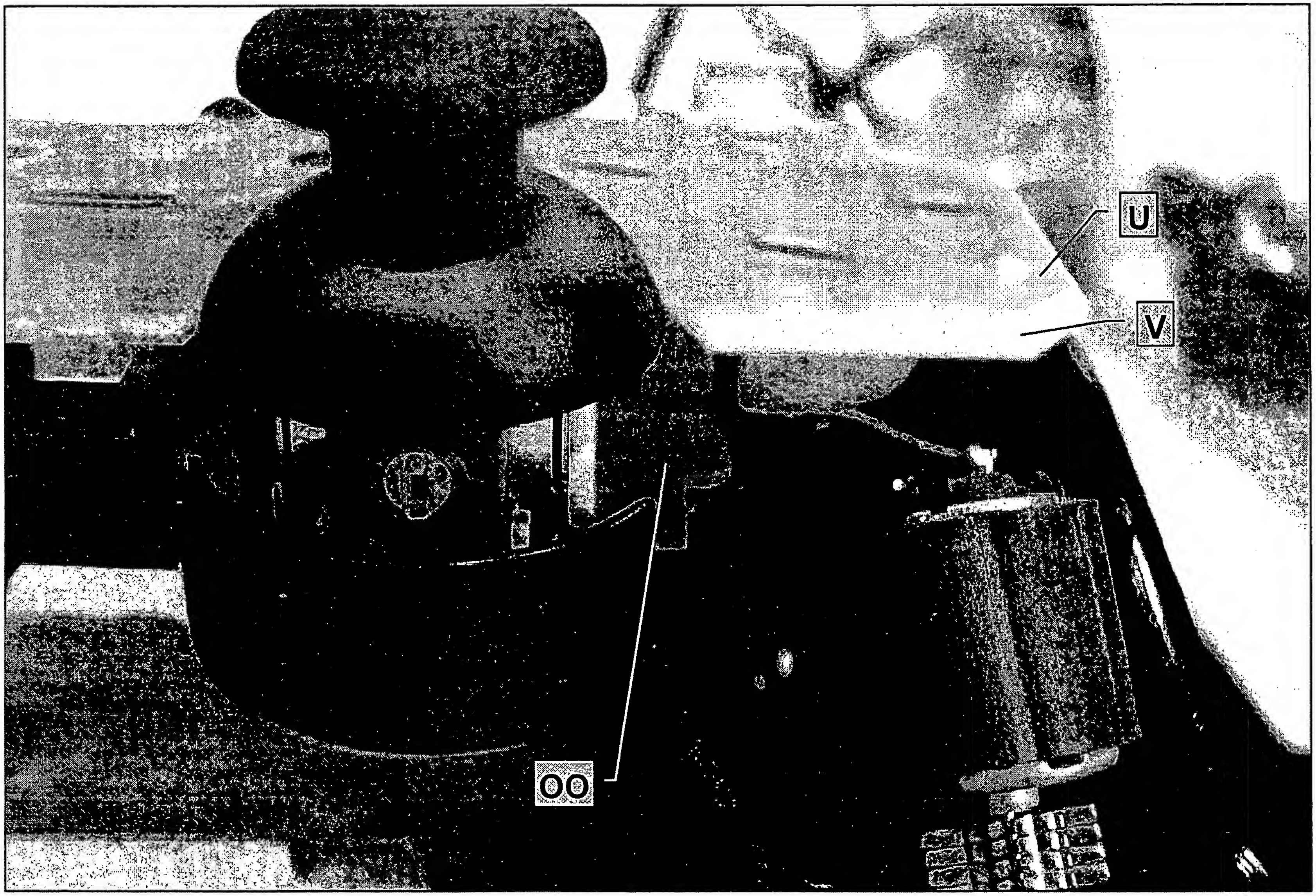

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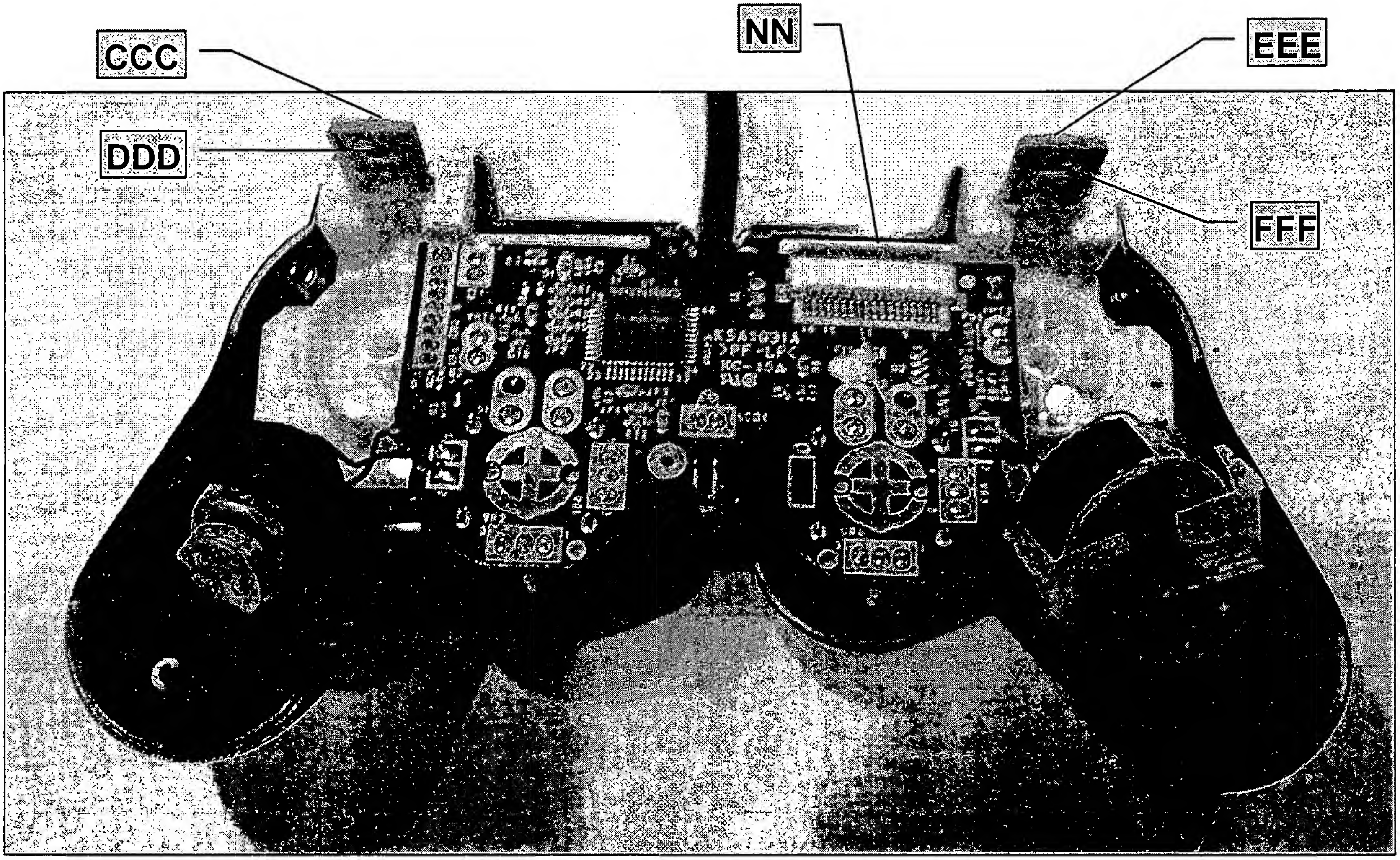

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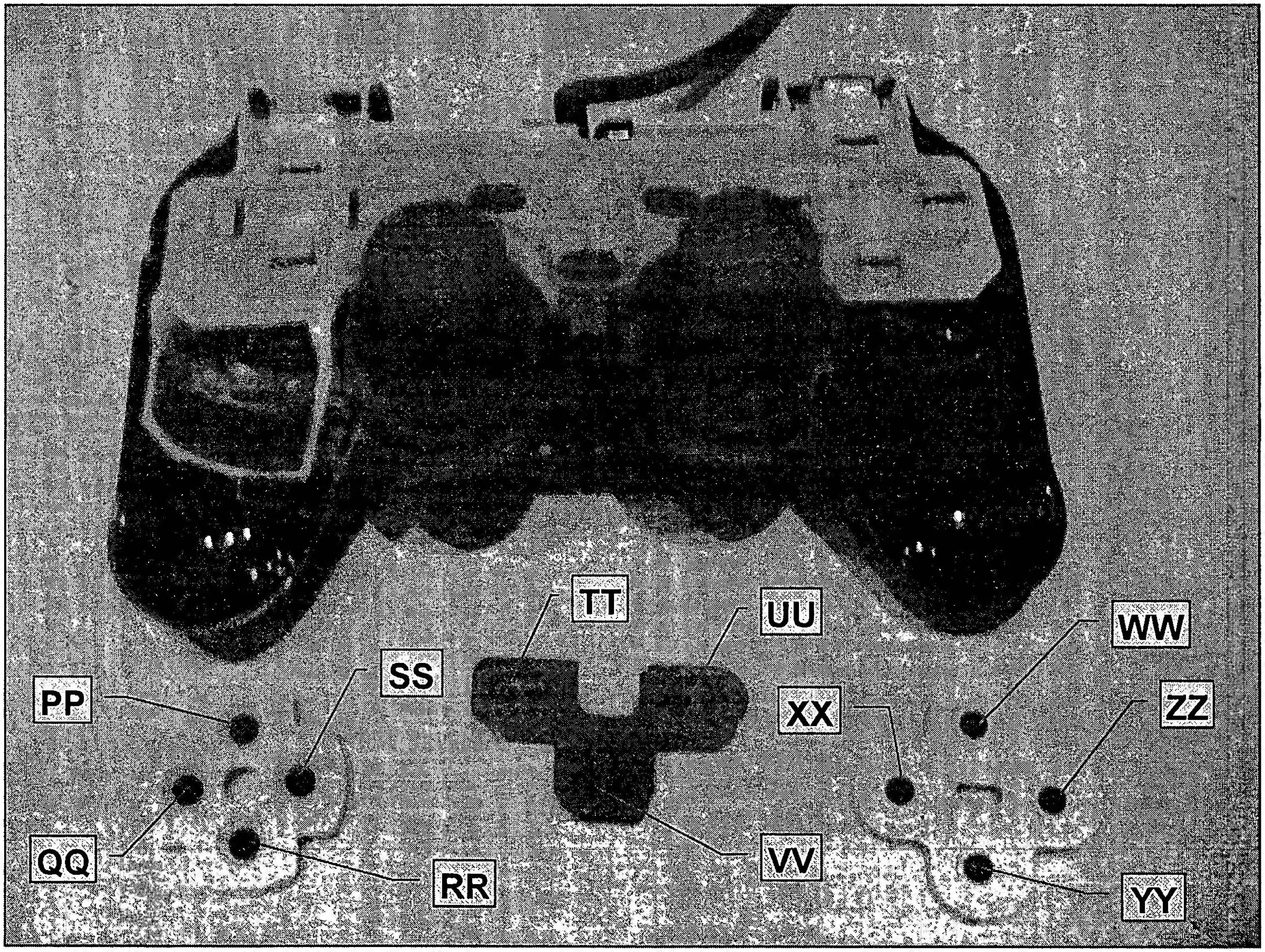
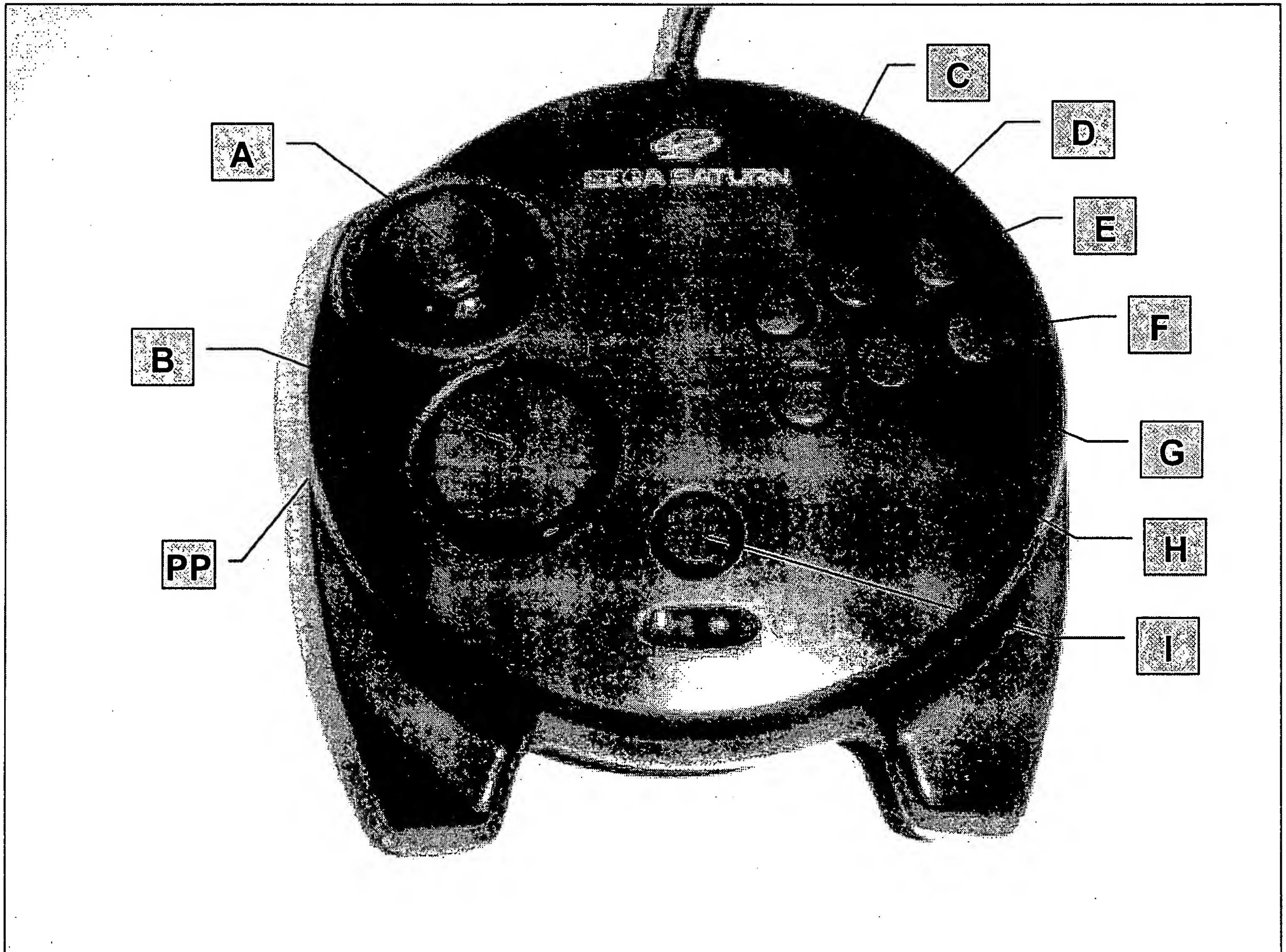


Sega Saturn 3D Control Pad



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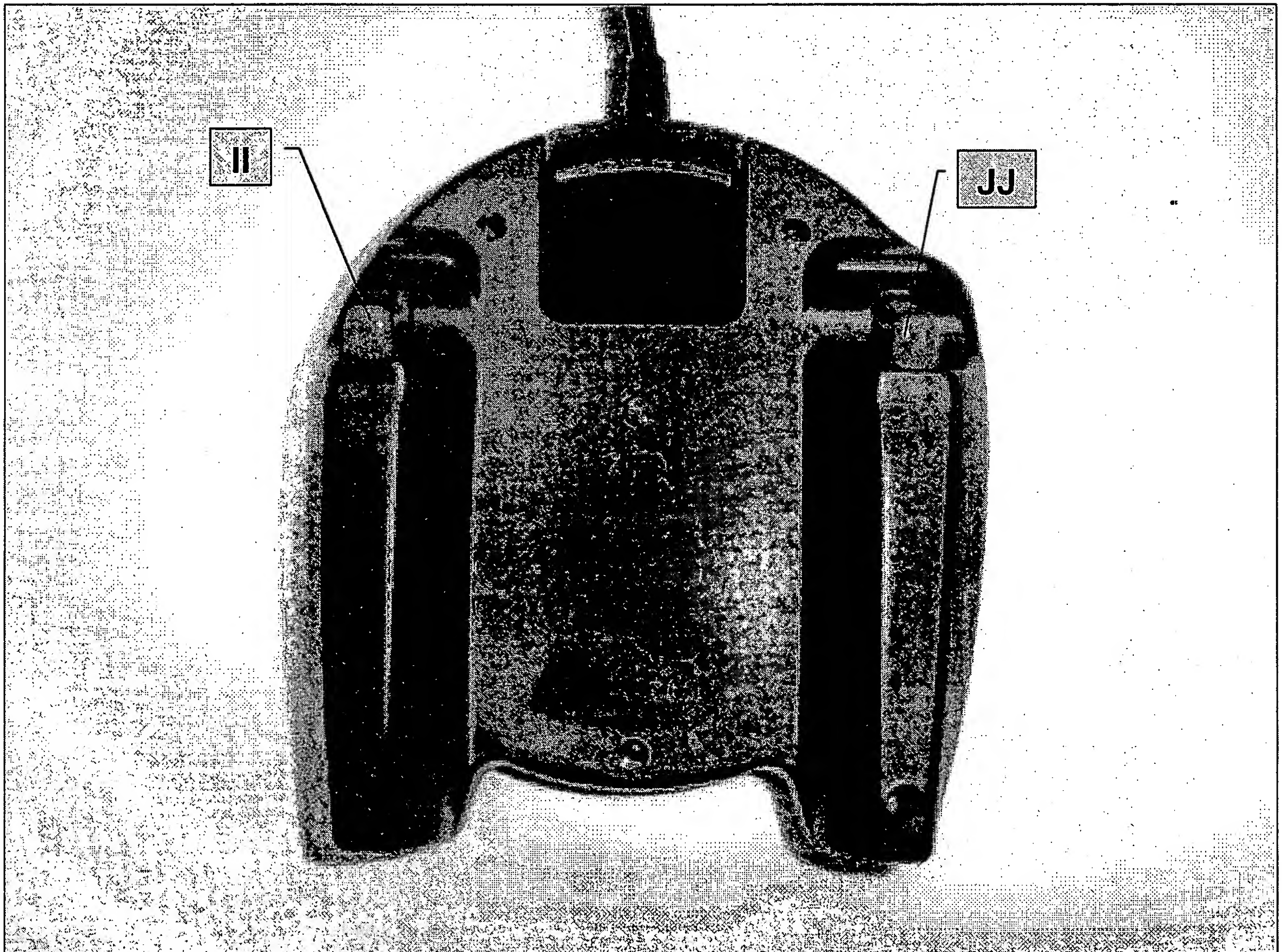
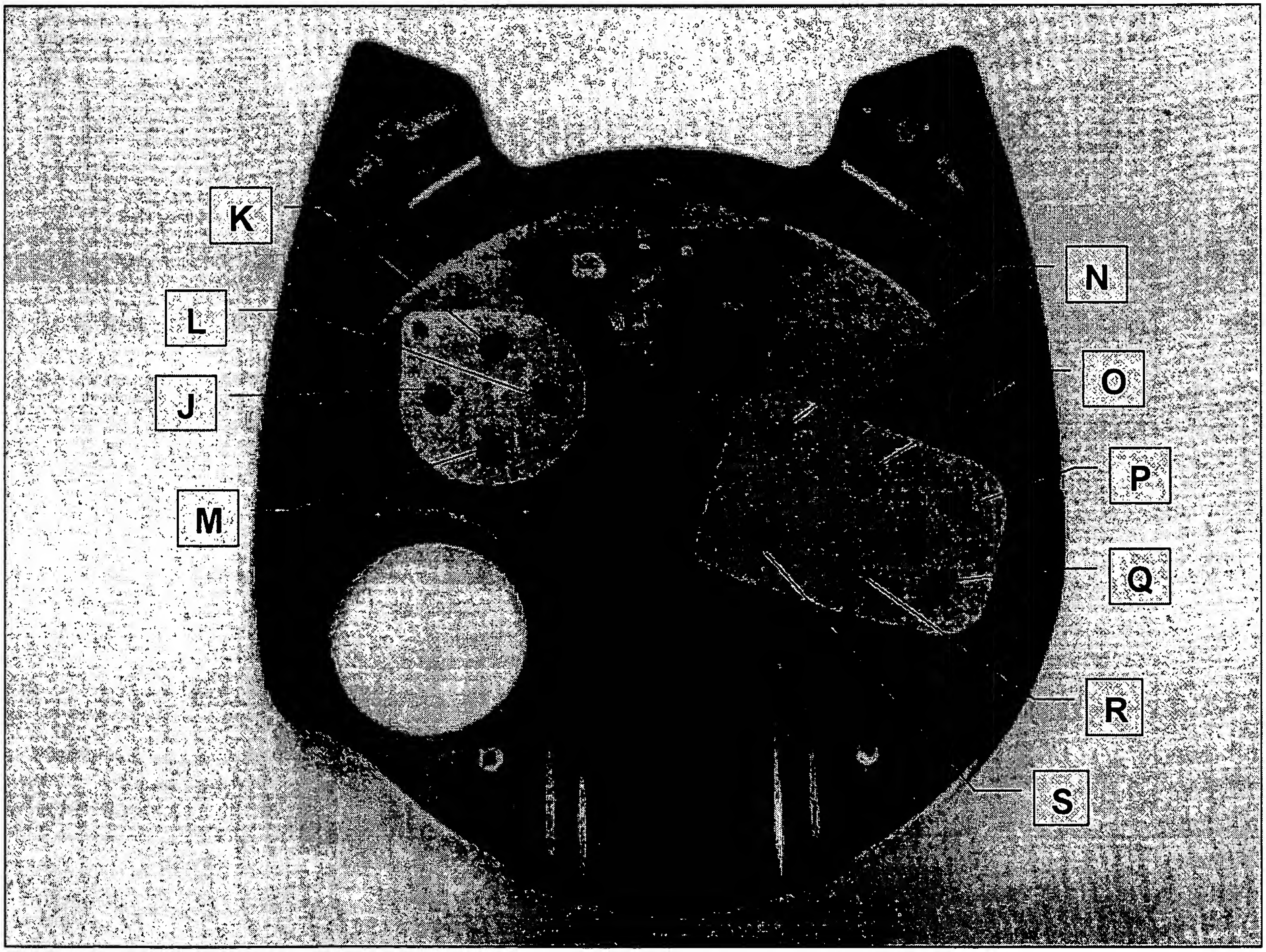
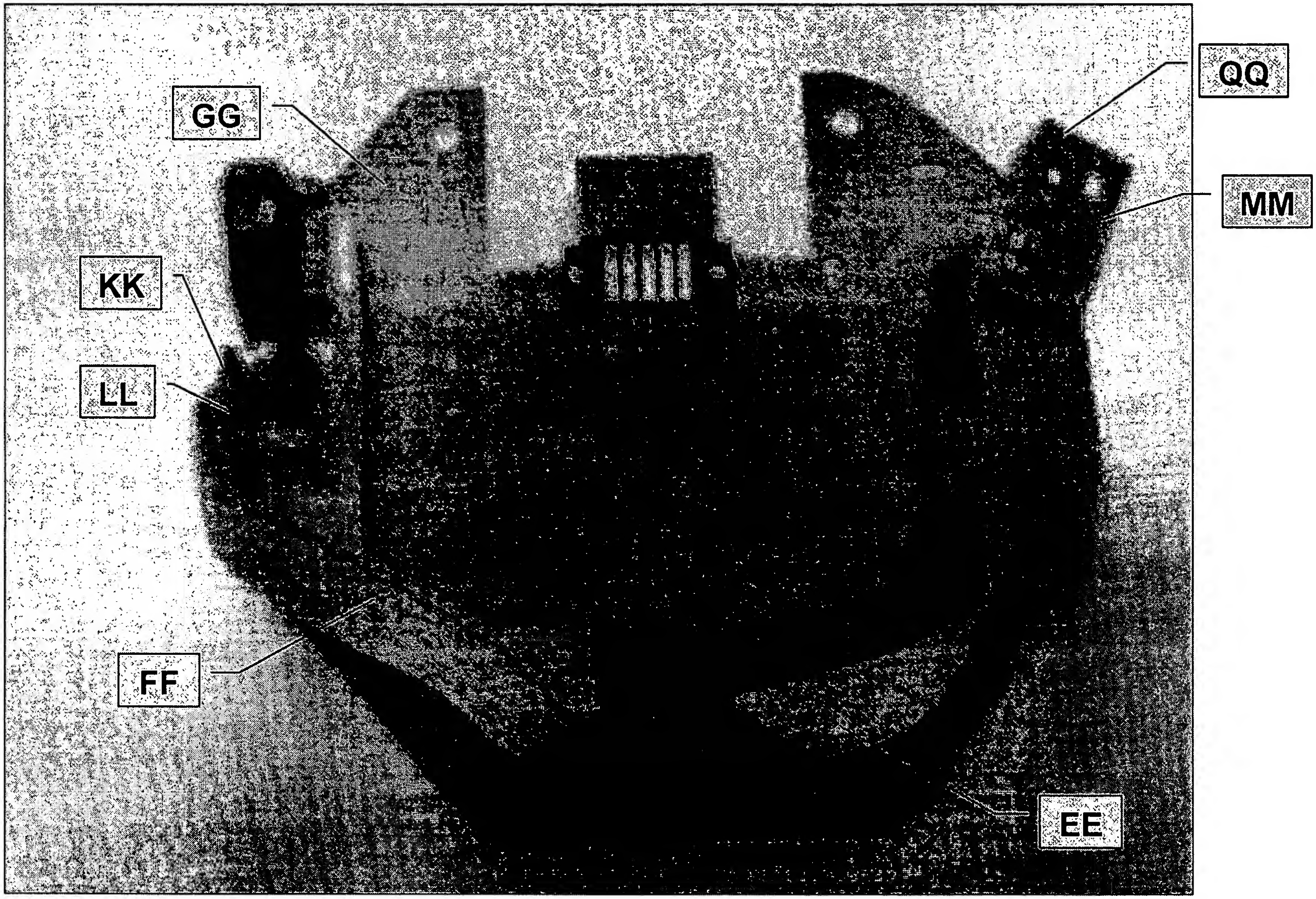


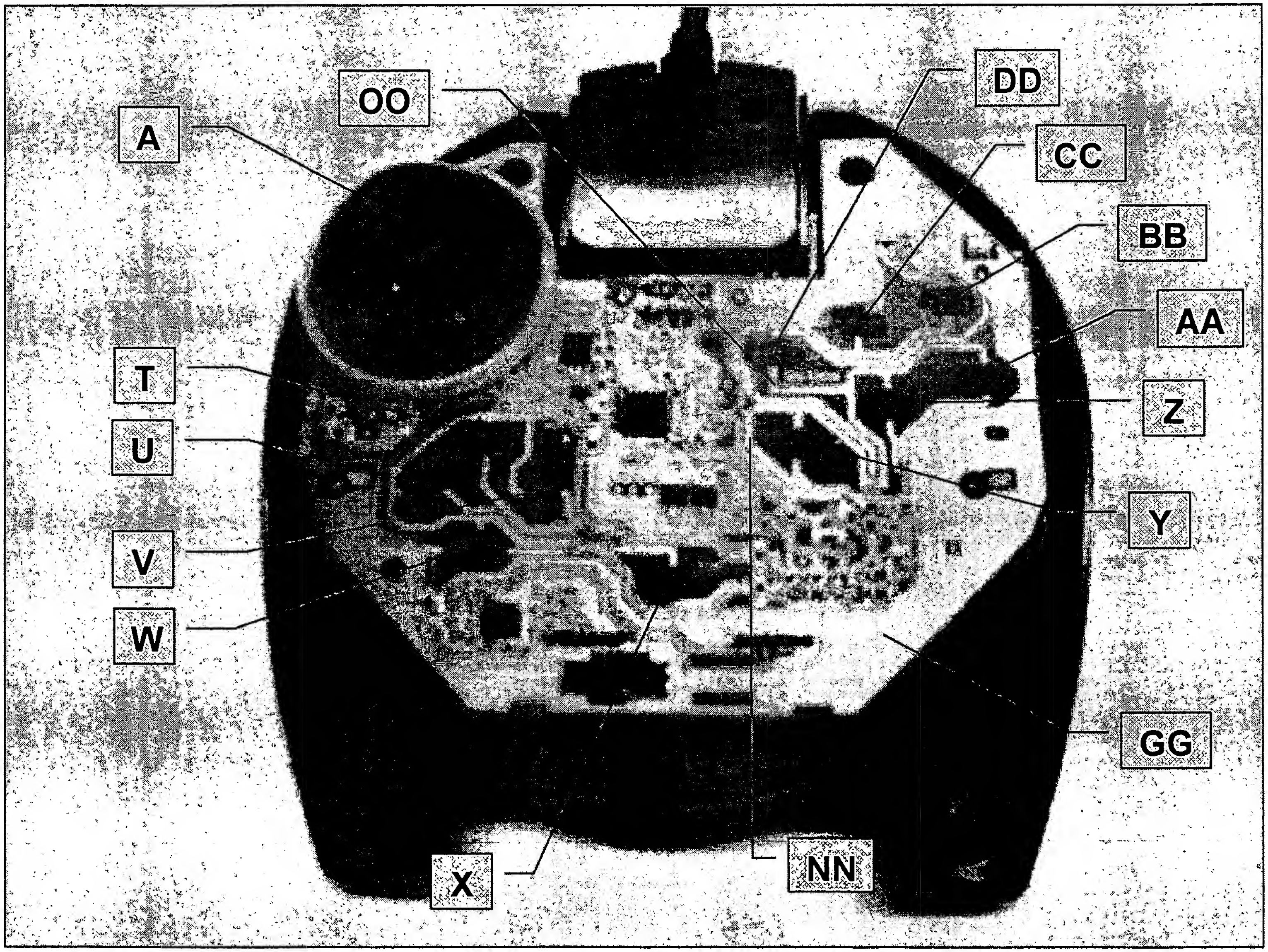
Sega Saturn 3D Control Pad



Sega Saturn 3D Control Pad



Sega Saturn 3D Control Pad




PlayStation
NTSC U/C
PlayStation
R4
RIDGE RACER TYPE 4
EVERYONE
E
CONTENT RATED BY
ESRB
SLUS-00797
namco

WARNING: READ BEFORE USING YOUR PlayStation® GAME CONSOLE:
A very small percentage of individuals may experience epileptic seizures when exposed to certain light patterns or flashing lights. Exposure to certain patterns or backgrounds on a television screen or while playing video games, including games played on the PlayStation® game console, may induce an epileptic seizure in these individuals. Certain conditions may induce previously undetected epileptic symptoms even in persons who have no history of prior seizures or epilepsy. If you, or anyone in your family, has an epileptic condition, consult your physician prior to playing. If you experience any of the following symptoms while playing a video game – dizziness, altered vision, eye or muscle twitches, loss of awareness, disorientation, any involuntary movement, or convulsions – IMMEDIATELY discontinue use and consult your physician before resuming play.

WARNING TO OWNERS OF PROJECTION TELEVISIONS:
Do not connect your PlayStation game console to a projection TV without first consulting the user manual for your projection TV, unless it is of the LCD type. Otherwise, it may permanently damage your TV screen.

HANDLING YOUR PlayStation® DISC:
- This compact disc is for use only with the PlayStation game console.
- Do not bend it, crush it, or submerge it in liquids.
- Do not leave it in direct sunlight or near a radiator or other source of heat.
- Be sure to take an occasional rest break during extended play.
- Keep this compact disc clean. Always hold the disc by the edges and keep it in its protective case when not in use. Clean the disc with a lint-free, soft, dry cloth, wiping in straight lines from center to outer edge. Never use solvents or abrasive cleaners.

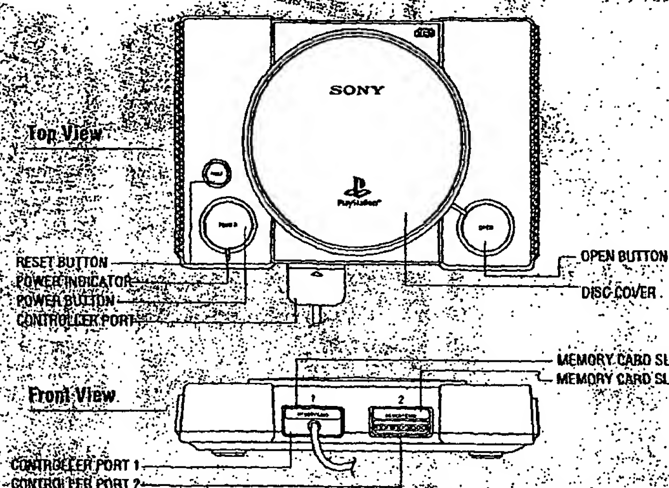
Contents

R4 RIDGE RACER TYPE 4

Setup

To load and run R4 RIDGE RACER TYPE 4 on your PlayStation® game console, follow these simple instructions:

Set up your PlayStation game console according to the instructions in its Instruction Manual. Make sure the power is off before inserting or removing a compact disc. Insert the R4 RIDGE RACER TYPE 4 disc and close the disc cover. Insert game controller(s) and turn on the PlayStation game console. Follow on-screen instructions to start a game.



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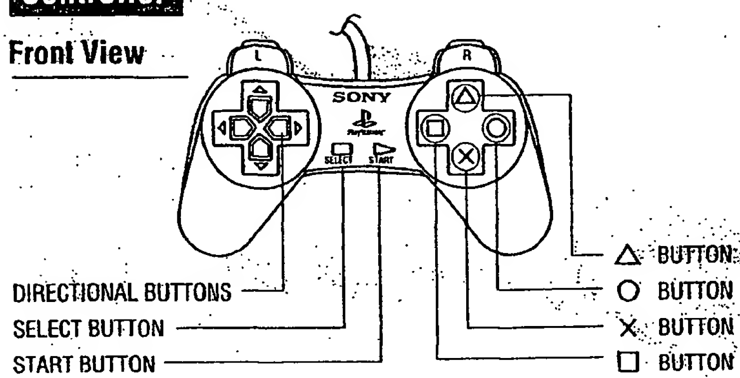
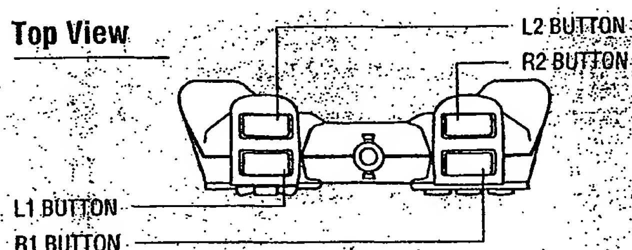
Controls

Controller

Front View



Top View

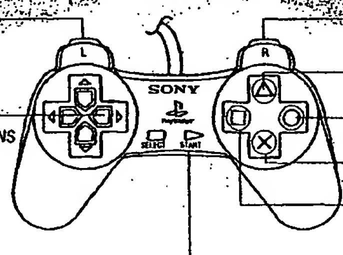


Basic Operation

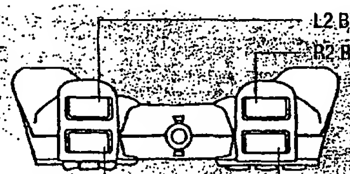
Standard Controller: Default Settings

The diagram below describes how to use the Standard Controller. In addition to this controller, R4 Ridge Racer Type 4 also allows the use of controllers such as the *NegCon*, *Jogcon*, and the *Analog Controller (Dual Shock)* (each sold separately).

Front View



Top View



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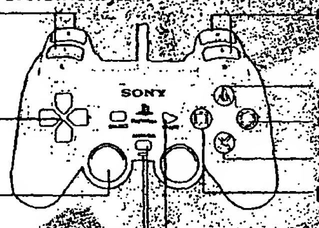
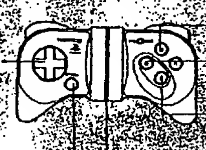
Analog Controller (Dual Shock): Default Settings

The Analog Controller gives you enhanced steering control with the Analog Stick. The controller will also vibrate whenever your car is involved in collisions (Dual Shock version only).



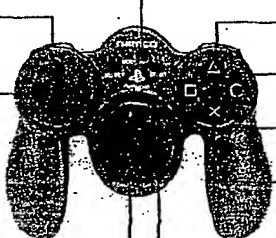
NegCon: Default Settings

The NegCon simulates the subtle nuances of a steering wheel by allowing you to turn the car with a left/right twisting motion.



Jogcon: Default Settings

The Jogcon provides an enhanced simulation of a steering wheel with a Dial located at the center of the controller. A motor attached to the Dial creates a force-feedback effect to imitate the feel of a steering wheel under actual driving conditions.



* WHEN THE JOGCON MODE IS TURNED OFF (LED OFF), THE JOGCON OPERATES LIKE A STANDARD CONTROLLER. SEE PAGE 4 FOR MORE INFORMATION.

Safety Mode

For safety purposes, the force feedback system will shut off after 60 seconds if no button presses are made or if a button is held down for 60 seconds (this excludes the Dial and MODE Switch). When this happens, it does not mean the Jogcon is malfunctioning. The force-feedback system will switch on again when a button press is detected. (When the controller switches in to Safety Mode, the words "SAFETY MODE" will be displayed on the screen.)

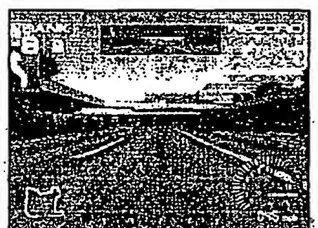
Operating the Dial

The basic technique is to hold the controller as shown to the right and move the Dial using your left and right thumbs (place each hand on the Jogcon's handles and wrap your other fingers around the handle for support).

Before a race starts, the Dial may rotate automatically in order to center itself. When this happens, lift your thumbs off the Dial and wait until it has stopped moving.

Jogcon Screen Display

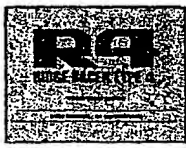
When you are using the Jogcon, a centering gauge will be displayed on the screen. You can turn this display on and off during a race by pressing the SELECT Button.

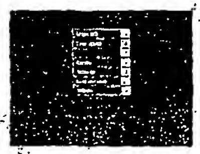


Centering Gauge

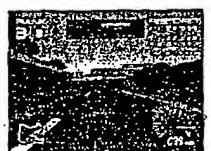
Game Modes

From the Title Screen, press the START Button to proceed to the Mode Menu screen. Use the Directional Buttons to choose the mode you want, and then press the ◎ Button or START Button to select.



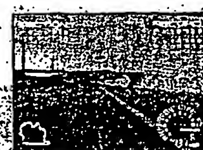


Grand Prix (Details Page 10)

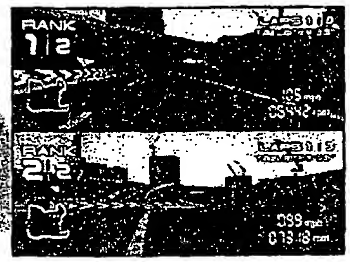


Grand Prix is the main game mode where you assume the role of a professional driver in a racing team. You must work together with the team manager to advance through the 1st and 2nd qualifying heats to compete in the final Grand Prix. Through a total of 8 races, you must complete the required laps for each course and finish in a qualifying position to go on to the next race in the competition. You achieve victory when you finish 1st in the final race.

Time Attack (Details Page 16)



In this mode, you race your machine of choice on a race-course by yourself. The goal in Time Attack is to defeat the record time for that course. In addition to the preset cars, you can also use cars that you've earned in a Grand Prix race. (However, only cars registered in the Garage can be used. This also applies in other modes as well.)



VS Battle (Details Page 19)

You and a friend can compete in head-to-head competition, with the screen split into two sections (top and bottom). As in Time Attack, you can race new cars earned in Grand Prix mode.

Garage (Details Page 21)

You can use the Garage to register cars that you've earned in the Grand Prix. Once a car is in the Garage, you can use them in the Time Attack and VS Battle modes. Registered cars can be customized with new paint jobs and preset decals. You can also create your own original decals to customize your car even more!

Records (Details Page 30)

In this mode, you can view trophies you've earned in Grand Prix mode as well as your course records in Time Attack mode.

Save & Load (Details Page 30)

Load and save game data. R4's PocketStation Garage applet can also be saved in this mode.

Options (Details Page 31)

You can change settings for controllers, screen display, and sound volumes here. You can also access the Music Player feature here to listen to the music in the game.

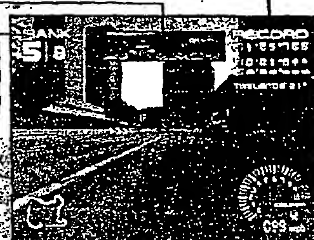
Grand Prix

You're a professional race driver. It's your job to sign up with a race team and try to win 8 Grand Prix races. As your driving skills improve (based on your finishing position), your team owner and manager will invest in newer, faster cars for you. Once you've won the final race, you'll be able to keep these cars as your own and place them in the Garage. **(Note: To skip comments in Grand Prix mode, press the START Button.)**

Screen Display

Two views are available during each race: *Driver's View* (showing the road from the driver's position) and *Overhead Cam* (located slightly above and behind the vehicle). During a race, use the Ⓐ Button to switch between these two views. Your operation of the car will not be affected, but *Driver's View* is recommended for achieving maximum realism.

Driver's View



Rear-View Mirror
Allows you to see behind you. This feature is not available in *Overhead Cam* view.

Position
Current position in race.

Record
Fastest lap time for this course.

Lap Time
Displays your lap times.

Time Limit
Time remaining in race. If you cannot finish the race before time counts down to zero, you must drop out of the race.

Tachometer
Revolutions per minute.

Gear
Displays the current gear position.

Speed
Current speed.

Course Map
Overall map of the course. Also shows the current location of your car.

Overhead Cam

Basic Rules

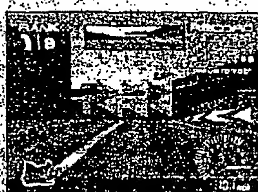
1 The Grand Prix is divided into 3 stages: The 1st and 2nd qualifying heats (2 races each) and the Final Grand Prix (4 races). You must complete the required laps for each race and finish in a qualifying position in order to advance to the next race.

2 If you do not place high enough to qualify for the next race, or you are not able to complete the race within the time limit, you must retire from the race.

3 After dropping out of a race, you are presented with the following options:

Retry	You have 4 chances to qualify in the same race. The game is over when you fail to qualify, and you have no more chances left.
End	Exit from Grand Prix mode.

4 You achieve ultimate victory when you advance through the first 7 races and finish 1st in the final race of the Grand Prix.



Pause Menu

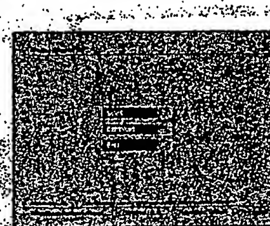
You can pause the game by pressing the START Button during a race. When the Pause Menu is displayed, choose between the 2 options by using the Directional Buttons on your controller, and press the START Button to select.

Cancel
Undo pause.

Retire
Retire from race.

Continuing A Saved Game

From the Mode Menu, choose *Grand Prix* and press the ◎ Button to select. If you have saved data available, you will be given the option to *Start* or *Continue*. Choose *Start* to begin a new Grand Prix competition from the beginning, or choose *Continue* to continue a previously saved race.



Selecting A Team

Use the Directional Buttons to choose a team from the 4 available teams, and press the ◎ Button to select. Each team's cars have different designs and some team's cars may be more difficult to drive than others. For more details on teams, see page 34.

Selecting A Car Manufacturer

After you are introduced to your new team, you will see the Maker Select Menu. Use the Directional Buttons to choose the manufacturer of your choice and press the ◎ Button to select. Each manufacturer has a distinctive design style and driving characteristics. For more details on each manufacturer, see page 33.

Car Data Menu Screen

This screen allows you to view detailed information about the car you have selected.

Maker Name
Automobile manufacturer selected.

Team Name
Name of selected team.

Car Name
Name of car.

Max Speed
Maximum speed.

Stage
Car Category:

Stage 1 Heat 1 Car
Stage 2 Heat 2 Car
Stage 3 Final GP Car
Stage 4 Final GP / Final Race Car

Type
Type of vehicle (DRIFT or GRIP). See page 37-38.

O.K.

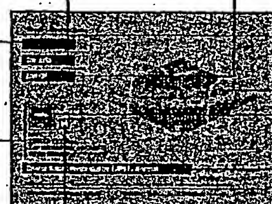
Proceed to transmission selection (AT or MT).

AT or MT

After selecting *O.K.*, choose between *AT* (automatic transmission) and *MT* (manual transmission) using the up/down Directional Buttons.

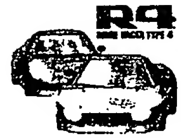
Course Data Menu Screen

When you are ready to start the race, use the up/down Directional Buttons to choose *Start* and then press the ◎ Button to select. Each of the eight races in the 1st and 2nd qualifying rounds and the final round are run on a different course. For details on the characteristics of each course, see pages 35-36.



Race Start Screen

The Race Start Screen is displayed as the race is about to begin. At this time you can use the left/right Directional Buttons to choose the background music for the race.

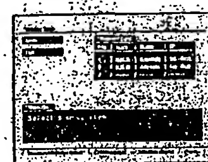


New Car Investment

Your team will invest in a new car prior to Heat 2, Final GP, and the final race of the Grand Prix. Your race performance will directly affect the kind of car your team purchases for you. The better your performance, the better the car you'll get. If your driving skills are deemed too low, you may have to settle for just a tune-up on your old car.

Saving Data

You can save a Grand Prix race in progress immediately after completing Heat 1 or 2. You also have a chance to save your race after the 3rd race of the Final Grand Prix. However, newly acquired cars cannot be registered in the Garage until you win the entire Grand Prix. After selecting the Save option, choose a save file with the up/down Directional Buttons and press the ◎ Button to save. You can save up to 3 Grand Prix races.



* Warning: You will lose all data from a previously saved game file if you overwrite that file with a new saved game.

Save	Saves Grand Prix game data. Note that Grand Prix, Time Attack, Garage, Record, and Options data are all saved in a single saved game file. Only one saved game can exist on a single Memory Card. All old data will be erased when new data is recorded.
Exit	Return to the game screen.

Game Over

The game is over when you fail to qualify for a race, and you have used up all your chances to retry the race. The game also ends when you select the *End GP* option.

▶▶▶

Time Attack

In this mode, you race your machine of choice on a racecourse by yourself. The goal in Time Attack is to defeat the record time for that course. In addition to the preset cars, you can also use cars that you've earned in a Grand Prix race. (However, only cars registered in the Garage can be used.)

Basic Rules

At the beginning only four courses are available for Time Attack, but the final four courses become available after the player makes it past the qualifying heats into the final round of a Grand Prix.

Note: In Time Attack, a player must retire from the race if he or she drives backwards before the timer starts or drives backwards for a full lap around the course.

Screen Display

Time Attack displays *Section Time* in place of *Driver Position* displayed in Grand Prix mode. Also there is no time limit, and the rear-view mirror is not displayed.

Section Time
Time for each section of the course.

Difference
The difference between the last section time and the fastest record time for that section. "-" means that the player's time is faster than the record time, and "+" means that it is slower.

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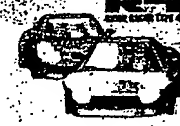


Course Select Menu Screen

Choose between courses using the left/right Directional Buttons. Choose between menu options with the up/down Directional Buttons, and press the ◎ Button to select.

O.K.	Proceed to the Car Select Menu.
Save	Saves game data. Note that Grand Prix, Time Attack, Garage, Record, and Options data are all saved in a single saved game file. Only one saved game can exist on a single Memory Card. All old data will be erased when new data is recorded.
Exit	Return to the Course Select Menu.

Car Select Menu Screen

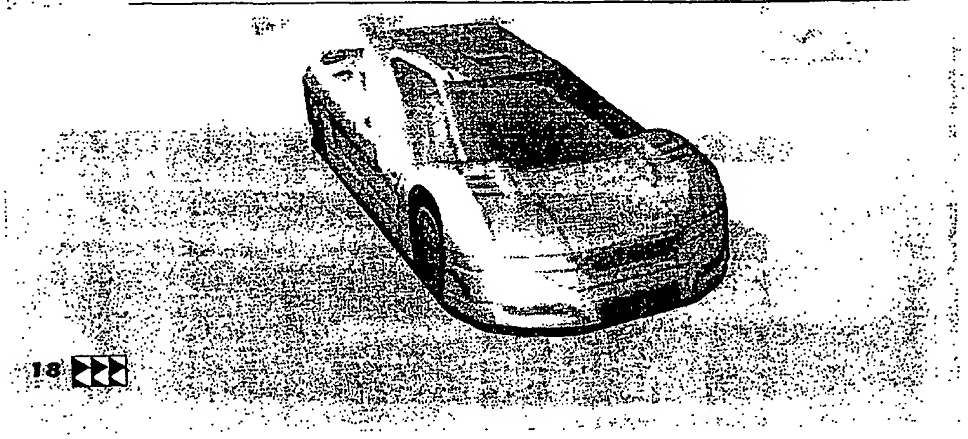
Both preset and new cars you've registered in the Garage are available in this menu. After choosing the car you want with the left/right Directional Buttons, place the cursor on *Start* and press the ◎ Button to select.

Start	Select transmission type (AT or MT) and proceed to the Race Start Screen.
Garage or Preset	Switch between the preset cars and the cars you've registered in the Garage with the ◎ Button. Choose the car you want with the left/right Directional Buttons.
Exit	Return to the Course Select Menu.

End of Time Attack

After completing the race, your lap times and total race time will be displayed first, followed by your overall ranking. Use the up/down Directional Buttons to choose from the menu items and press the ◎ Button to select. If your time ranking is within the top 5, you can enter your name into the records. Use the left/right Directional Buttons to move the cursor and the up/down Directional Buttons to choose letters. Once your name is entered in correctly, press the ◎ Button to select.

Retry	Retry Time Attack race on the same course.
Car & Course Change	Change car or course and play Time Attack again.
Exit	Return to the Mode Menu.



VS Battle

You and a friend can compete in head-to-head competition, with the screen split into two sections (top and bottom). As in Time Attack, you and your competitor can race new cars earned in Grand Prix mode. (However, only cars registered in the Garage can be used.)

Basic Rules

1 The player to complete the required number of laps first wins.
2 The race is over when the first player crosses the finish line.

Screen Display

In VS Battle mode, the screen is split into top and bottom sections. Player 1's car is displayed on top, and player 2's car on the bottom.

1P
2P


Car Select Menu Screen

Both preset and new cars registered in the Garage are available in this menu. After choosing the car you want with the left/right Directional Buttons, place the cursor on *Start* and press the ◎ Button to select. Player 1 selects first.

O.K.	Proceed to Course Select Menu.
AT or MT	Choose between automatic (AT) or manual (MT) transmission.
Load	Load car data from the Garage. Player 1 loads car data from Memory Card Slot 1 and player 2 loads from Slot 2.
Garage or Preset	Switch between the preset cars and the cars you've registered in the Garage with the ◎ Button. Choose the car you want with the left/right Directional Buttons.
Exit	Return to the Mode Menu.

Course Select Menu Screen

Choose a course by using the left/right Directional Buttons. You can also set the number of laps as well as the number and skill level of cars driven by the computer. You can change these settings by selecting the appropriate menu item and using the left/right Directional Buttons within each menu. When you have changed the settings to your liking, use the Directional Buttons to choose *Start* and then press the ◎ Button to select.

Start	Start the race.
Laps	Choose from 2 to 9 laps.
Com car	*Number* determines the number of cars driven by the computer (up to 2), and *Level* sets their skill level (1 [Weak] to 4 [Strong])
Exit	Return to the Car Select Menu.

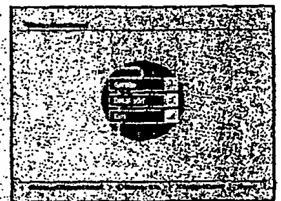
End of VS Battle

When the race is complete, results will be displayed showing the winner and loser. Use the up/down Directional Buttons to choose a menu option and press the ◎ Button to select.

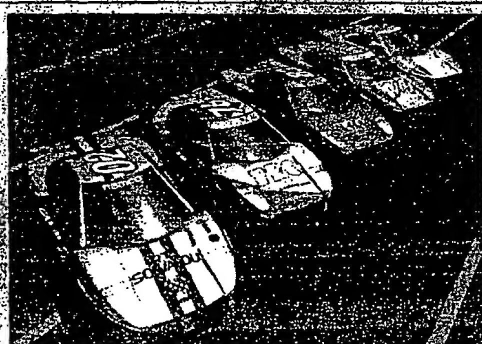
Retry	Retry VS Battle race on the same course.
Car & Course Change	Change car or course and play VS Battle again.
Exit	Return to the Mode Menu.

Garage

You can use the Garage to register cars that you've earned in the Grand Prix. Once a car is in the Garage, you can use them in the Time Attack and VS Battle modes. Registered cars can be customized with new paint jobs and preset decals. You can also create your own original decals to customize your car even more!



Garage	Register cars acquired in Grand Prix mode or change the decal on a car. See page 23 for more details.
Decal Edit	Create a new decal for your car. See page 25-29 for more information.
Exit	Return to the Mode Menu.



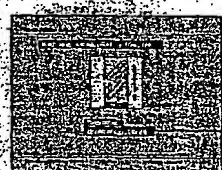
New Car Registration

There are 8 preset cars initially registered in the Garage. When you finish an entire Grand Prix race, these preset cars are replaced automatically with any newly acquired cars. However, once you have accumulated 9 or more new cars, additional cars will simply be added to the Garage without being registered. You MUST register these new cars in order to use them. To register them, or to customize your car, choose *Garage* and press the ◎ Button to select.

Change Car

When you want to replace one of your 8 registered cars with another car in your Garage, choose the car you want to replace with the right/left Directional Buttons, select *Change car* and press the ◎ Button.

Identify the new car you want to register by team and manufacturer, and then select the car number.



Number of Cars
Number of cars you have / total number of cars available (A flashing number next to a team or manufacturer's name means that a new car is available for that team or manufacturer.)

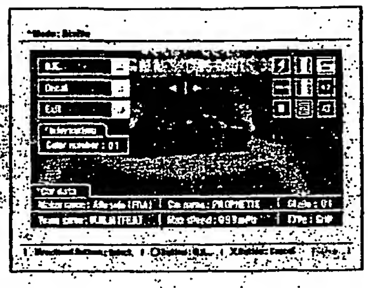
Selected
When this is displayed, the car cannot be selected since it is already registered.

Status Box
These numbered boxes show the cars you have acquired so far. The currently selected car is shown in orange, the cars in your possession are in yellow, and the cars you don't have yet are transparent.

Car Number
Car number (a flashing number signifies that the car has just been added).

Design

You can customize a car by choosing it with the left/right Directional Buttons and selecting the *Design* menu item by pressing the ◎ Button.



Change Car Color

When the Design Menu is displayed, use the left/right Directional Buttons to choose the desired color and press the ◎ Button to select it. Color availability will vary among manufacturers.

Change Car Decal

Choose *Decal* from the Design Menu and press the ◎ Button to select it. The Decal Select Menu will appear and sample decals will be displayed on-screen. Use the left/right Directional Buttons to choose the decal you want and press the ◎ Button to select it. Decal #0 is reserved for your original decal (see page 25-29 for more information). If you have not created a decal, choosing decal #0 will result in a solid-colored car (Note that a car with color #0 cannot have a decal). When you're finished with all your changes, choose *O.K.* on the Design Menu and press the ◎ Button.

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Save

This menu item allows you to save data. First enter a name for your Garage. Use the Directional Buttons to highlight characters and press the ◎ Button to enter them. If you made a mistake, press the ⊗ Button to erase a character and back up the cursor. The name of your Garage can be up to 8 letters long. When you are finished entering your name, move the cursor to *End* and press the ◎ Button to save.

*Warning: Grand Prix, Time Attack, Garage, Record, and Options data are all saved in a single saved game file. Only one saved game can exist on a single Memory Card. All old data will be erased when new data is recorded.

Exit

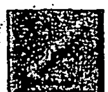
This returns you to the Mode Menu.

Decal Edit

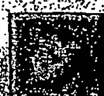
R4 comes with several sample decals for you to use right away, but you can also create your own custom decal and install it on your car. To create your own decal, choose the *Decal edit* menu item and press the ◎ Button to select.

Icons

The icons on the screen represent various functions which can be performed by moving the cursor over the desired icon and pressing the ◎ Button. Each icon functions as follows:



Pen
Draws at the cursor position.



Paint
Paints over an area of color around the cursor position with a new color.

Line
Draws a straight line.

1. First press down on the ◎ Button inside the edit window.
2. Keeping the ◎ Button held down, move the cursor to a new position.
3. Release the ◎ Button. A straight line will be drawn between the two points.

Eraser
Erases a point at the cursor position, leaving it transparent.

Palette
Selects the color used in *Pen*, *Line* and *Paint* functions.

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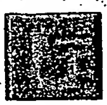
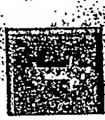
Size
Changes the size of the *Pen*, *Line* and *Eraser* functions. With the cursor over the *Size* icon, press the ◎ Button to cycle through 1x1, 2x2, 4x4, and 8x8 sizes.

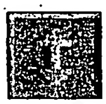


Undo
Undo the last function and return the edit window to its previous state (pressing the ◎ Button one more time will return the edit window to its original state before editing).

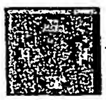
Rotate
Rotates the contents of the edit window 90 degrees clockwise.



Horizontal Flip
Flips the contents of the edit window horizontally.



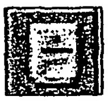
Vertical Flip
Flips the contents of the edit window vertically.



Move

1. Place the cursor over the move icon and press the ◎ Button to switch to *Move* mode. The cursor will automatically be relocated to the center of the screen.
2. Holding the ◎ Button down while you are in *Move* mode will change the cursor to the *Move Mode Cursor* (releasing the ◎ Button will change the cursor back to normal).
3. Move the *Move Mode Cursor* in the direction you want to move the edit window contents.

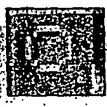
Erase Screen
Erases the contents of the edit window.



Memory Card
Save/load decal to or from a Memory Card.

⊗ Button Function
Allows you to assign a function to the ⊗ Button. You can cycle through the assigned function from *Dropper*, *Eraser*, and *Undo*.

Dropper
See next page.

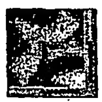


Magnifying Glass
Cycles the magnification level of the edit window from 1X, 2X, 4X, and 8X.

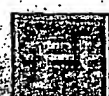
RGB Bar
Allows you to adjust the paint color accurately. Place the cursor over a color bar and press the ◎ Button to adjust the color value (You can change the color value in 1 unit increments by placing the cursor on the arrow icon at either ends of the bar and pressing the ◎ Button.).

Load Sample
Loads any of the preset sample decals to the edit window. Choose the decal you want by using the left/right Directional Buttons, and press the ◎ Button to select it.

* Warning: Loading a sample decal will erase the design that is currently in your edit window.

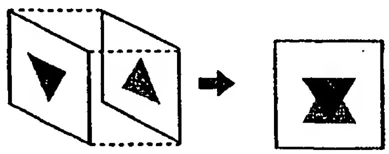


Scroll Bar
Scrolls the area displayed in the edit window up/down or left/right. Place the cursor on the arrow icon at either ends of the scroll bar or the bar itself to scroll the image.



Switch Layer Icon
Switches the top layer to the bottom and vice versa.

Copy Layer Icon
Copies the image from the top layer onto the bottom layer.



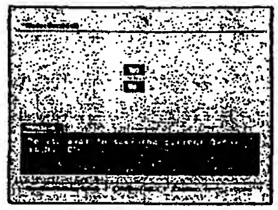
Layer Edit Function
In Decal Edit, it's possible to edit two separate images and then overlap them to create the final decal, as shown on the left. These two images are referred to as layers.

Decal Edit Shortcuts

The following shortcuts are available using the L1, R1, and ⊗ Buttons in Decal Edit:

L1 Button	Pressing the L1 Button makes the cursor jump back to the last function you used. If you hold down the L1 Button, you can select each function individually.
R1 Button	Holding the R1 Button down makes the cursor move faster.
⊗ Button (Dropper)	Pressing the ⊗ Button while inside the edit window will set the color of the *Pen*, *Line* and *Paint* functions to the color at the cursor position.

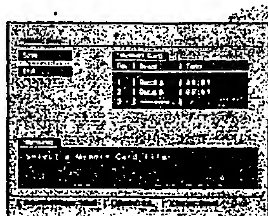
Decal Registration



When you are finished creating your decal, move the cursor to *O.K.* and press the ◎ Button. The decal will be registered as your own original decal and saved in decal location #0. You cannot register more than one sticker at a time. When you are finished, move the cursor to *Exit* and press the ◎ Button to return to the Garage Menu.

* Warning: You will lose any image in your edit window when you exit.

Save/Load Decal



Place the cursor on the Memory Card icon and press the ◎ Button. This will display the Save and Load Menu screen. After choosing *Save* or *Load* with the up/down Directional Buttons and pressing the ◎ Button, you can choose the Memory Card block to save the decal data to (or load from). You can save up to 3 decals, but you need to have 1 Memory Card Block for each decal you save.

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Records / Save and Load

Records

This mode allows you to review the Grand Prix trophies you've won as well as your time records in Time Attack.

Trophies	Shows the trophies you've won in Grand Prix mode.
Lap Records	Shows the top 5 lap times. To view car data, place the cursor over *Car data*, press the ◎ Button and use the up/down Directional Buttons to choose the record you want to view, and then press the ◎ Button again. This will show information about the car used to get the record. Use the left/right Directional Buttons to select records from another course.
Total Records	Shows the top 5 total race times. Use the same controls as in *Lap records* above to view information about the record.
Exit	Returns you back to the Main Menu.

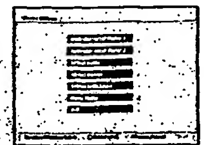
Save and Load

This mode saves and loads R4 game data. Choose a menu item with the Directional Button and press the ◎ Button to select. You can also save R4's PocketStation Garage Applet in this mode (See page 39-42 for more information.)

* Warning: Grand Prix, Time Attack, Garage, Record, and Options data are all saved in a single saved game file. Only one saved game can exist on a single Memory Card. All old data will be erased when new data is recorded.

Options

In Options, you can change your settings for controllers, screen display, and sound volumes. You can also access the Music Player feature here to listen to game music. Use the Directional Buttons to choose menu items and press the Button to select it.



Controller Setup: Player 1

This enables you to configure the settings for Player 1's controller. Use the left/right Directional Buttons to choose from 8 preset controller configurations and press the Button to select it. If you are using a Dual Shock Controller, you can turn *Vibration* on or off by using the up/down Directional Buttons.

If you are using a NegCon or Jogcon, you can adjust the steering setup for either controller after you choose the controller configuration by pressing the Button.

If you have a Negcon, hold the NegCon in an untwisted position and press the START Button. Next, choose the *Steering Play* amount with the left/right Directional Buttons and press the I Button to set it. Then use your left/right Directional Buttons again to choose the *Max Rotation* angle for the Negcon and press the I Button to finish the setup.

If you are using a Jogcon, set the Dial at the desired centering position and press the START Button. Next, choose the *Steering Play* amount with the left/right Directional Buttons and press the Button to set it. Then use your left/right Directional Buttons again to choose the *Max Rotation* angle for the Jogcon's Dial and press the Button. Finally, select the *Force Feedback Strength* amount with the left/right Directional Buttons to apply resistance to the Jogcon's Dial and press the Button to finish setup.

Controller Setup: Player 2

This allows you to configure the settings for Player 2's controller. Adjust settings as described above for Player 1.

Adjust Audio

This feature enables you to adjust the volume balance between the background music (*B.G.M.*) and sound effects (*S.E.*) during the game. First, choose either *B.G.M.* or *S.E.* with the up/down Directional Buttons and press the ◎ Button to select it. Next, use the left/right Directional Buttons to adjust the volume for that setting (setting it to the left will lower the volume) and press the ◎ Button to set it. You can also switch the audio output between *Mono* and *Stereo* output under the *Output* menu item (Enter the *Output* menu and use the left/right Directional Buttons to switch between the two settings.).

Adjust Screen

Use the left/right Directional Buttons to adjust the position of the screen.

Adjust Brightness

This is a reference screen that you can use to adjust the brightness setting on your television. For best viewing results during the game, adjust the brightness setting on your television so that all the circle marks on the screen are visible.

Music Player

The Music Player allows you to listen to the music that is played during the game. Use the left/right Directional Buttons to select a song. Press the ⊗ Button to exit the Music Player and return to the Options Menu. You can have a special display effect on the screen if you press the △ Button during music playback.

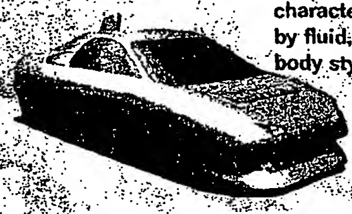
Exit

Return to the Main Menu.

Manufacturer Information

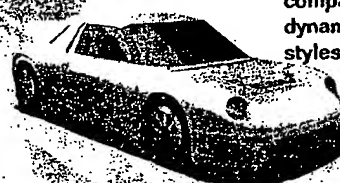
ASSOLUTO

Country	Italy
Type	Drift
Note	Assoluto's car designs are characterized by fluid, sporty body styles.



Age solo

Country	France
Type	Grip
Note	Their designs focus on compact, aero-dynamic body styles.

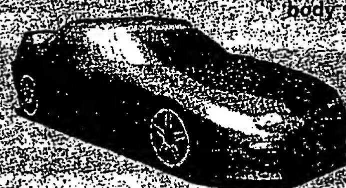


Lizard

Country	USA
Type	Drift
Note	Lizard's designs are noted for their dynamic and aggressive forms.

TERRAZI

Country	Japan
Type	Grip
Note	Terrazi is renowned for their varied body styles.



Team Descriptions

Racing Team Solvalou (RTS)

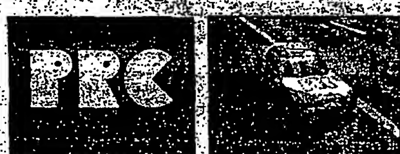
Tuning	Hard
Profile	An elite Italian team with a record number of GP victories. Their cars are tuned for high performance.

RC Micro Mouse Mappy (MMM)

Tuning	Easy
Profile	A French team with cars renowned for ease of handling. The team also has a new owner for this season.

Pac Racing Club (PRC)

Tuning	Normal
Profile	A new Japanese team competing for the first time this season. Their cars are tuned for balanced performance.



Dig Racing Team (DRT)

Tuning	Expert
Profile	A winning team in the past, this American team is in a slump. Their limited budget will make a winning season difficult to achieve.

Course Descriptions

There are a total of 8 different courses. The layout of each course differs greatly, so familiarize yourself with each one to develop your racing strategy. Although the race order for the courses are preset in the Grand Prix, you can choose courses freely in the other race modes.

Helter Skelter

Helter Skelter is set in a futuristic port city under development called Namco Mirai 22. Freeway overpasses block your view, so memorization of the course is a must.

Edge of the Earth

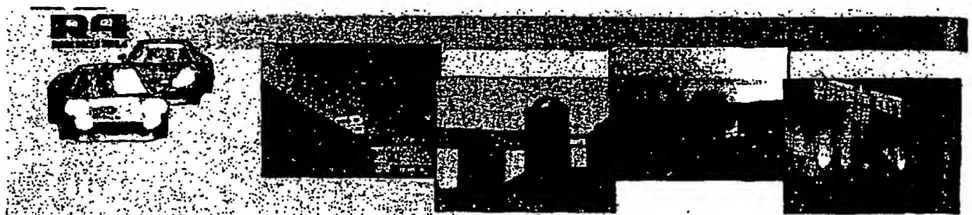
This is a night course with straightaways and devastating hairpin turns that require excellent driving skills. Don't get too distracted by the beautiful night scenery!

Wonderhill

Wonderhill is a course that winds through gently rolling mountains. While the passing scenery is beautiful, there are plenty of curves to keep your eyes on the road.

Out of the Blue

While it shares a section of track with *Helter Skelter*, this track goes through a port area, so you'll see warehouses and cargo ships. Beware of the right-angle turn near the docks!



Phantomile

Phantomile is the shortest course in the Grand Prix. Since the course is wider than the others, fast lap times will be determined by skillful and aggressive cornering.

Heaven and Hell

The first half of this course runs the same route as *Wonderhill*. The second half provides challenging curves that provide plenty of white knuckle racing thrills.

Brightest Night

This course shares a section with *Edge of the Earth* but it's one of the longest in the Grand Prix with 2 vicious hairpin curves. You'll have to master them to ensure victory.

Shooting Hoops

Shooting Hoops is an oval course that sets the stage for the final race of the Grand Prix. Speed is of the essence on this track. Even small mistakes may cost you the race!

Technical Advice

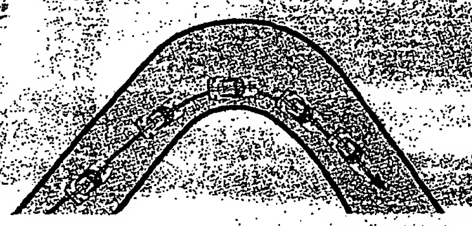
Acquaint yourself with the *Grip* and *Drift Cornering Methods*. These two cornering techniques form the basic backbone of racing strategies in R4. If you master them, you'll be on your way to ruling the courses!

Grip Cornering Method

This technique employs reduced velocity controlled with the accelerator. Reducing accelerator input right before a corner will increase tire grip and enable you to quickly slip through it. As you clear the corner, increase accelerator input to increase your speed onto the straightaway.

When you attack corners, stay outside of the course at the start of the curve, and then come close as possible to the inside of the course at the apex of the curve. As you come out of the curve, move to the outside of the course again.

This cornering method works well with Age Solo and Terrazzi Cars.

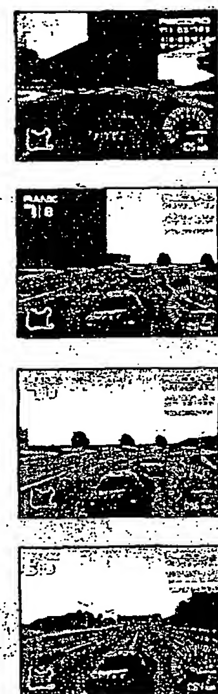


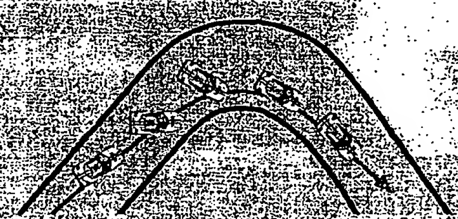
Drift Cornering Method

In the *Drift Cornering Method*, you must intentionally put your car into a controlled tail slide to negotiate a sharp corner. This method is well suited for cars by Assoluto and Lizard.

To use this method, turn steering sharply to the inside of the curve as you near the turn and ease up on the accelerator. By pressing the accelerator again, the tail of the car will slide, causing your car to "drift." The longer you release the accelerator and steering is turned into the curve, the stronger the tail slide will be when you reapply the accelerator.

After the tail slides, turn steering back towards the outside of the curve. As you exit the curve, let steering go neutral and press the accelerator to regain your speed.





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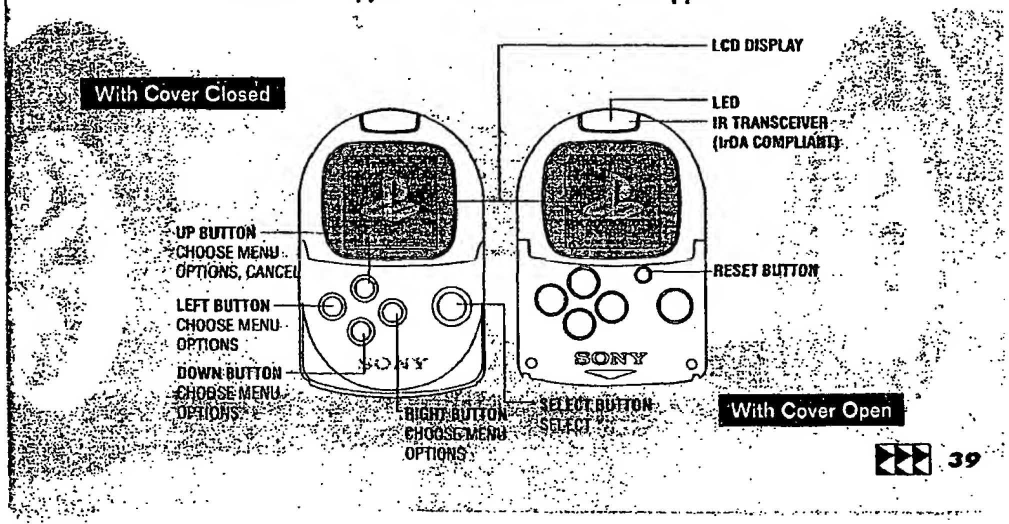
PocketStation

You can use the PocketStation with R4 to exchange cars earned in a Grand Prix with another PocketStation using infrared data transfer. To save the *R4 Garage Applet* onto a PocketStation, go to the *Save and Load* menu and select the *PocketStation* menu item. See the following pages for more information on setting up data transfers between two PocketStation.

* **Important Note: Using the *Save and Load* feature here only saves the *R4 Garage Applet* and not the actual R4 game data!**
* If you keep the PocketStation's SELECT Button held down for a few seconds, it will show a menu screen. You will then be given the option to *Exit* the PocketStation applet or *Continue* to use the applet.



Send Mode

This mode allows you to send data for cars you've earned in a Grand Prix to another PocketStation. (Your car data will not be erased when you do this.)

1. When the Title Screen is shown, press the SELECT Button to go to the *Send/Receive* menu. Choose *Send* using the up/down Directional Buttons and press the SELECT Button.
2. If car data is available, the *Team Select* menu is shown next. Choose the team using the left/right Directional Buttons and press the SELECT Button (If there is no car data available, you will be returned to the *Send/Receive* menu.). You can return to the *Send/Receive* menu by pressing up on the Directional Button.

Key to Team Abbreviations:

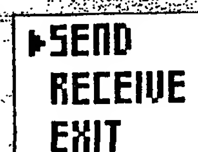
DRT	Dig Racing Team	**MMM**	Micro Mouse Mappy
PRC	Pac Racing Club	**RTS**	Racing Team Solvalou

3. If there is data available for the team you selected, the *Maker Select* menu will be displayed next (If there is no data available for the team you selected, you will be returned to the *Team Select* menu.). Choose the manufacturer using the left/right Directional Buttons and press the SELECT Button. You can also return to the *Team Select* menu by pressing up on the Directional Button.

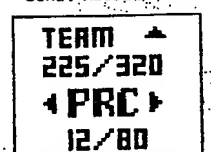
Key to Manufacturer Abbreviations:

AST	Assoluto	**LZD**	Lizard
TRZ	Terrazi	**AGS**	Age Solo

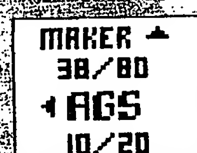
Title Screen



Send / Receive Menu

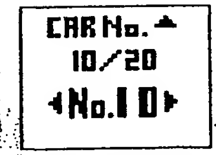


Team Select Menu



Maker Select Menu

4 If data is available for the manufacturer you selected, the *Car Number Select* menu will be displayed next (If there is no data available for the manufacturer you selected, you will be returned to the *Maker Select* menu.). Choose the car number using the left/right Directional Buttons and press the SELECT Button. You can return to the *Maker Select* menu by pressing up on the Directional Button.



Car No. Select Menu

5 Once you have completed the settings in numbers 1 through 4 above, the *Send Confirmation* menu is shown. If you want to send the car data, make sure the other PocketStation is displaying the *Receive Screen* and press the SELECT Button. If you want to make changes before sending the data, press up on the Directional Buttons. You will be returned to the *Car Number Select* menu.

Send Confirmation Menu

Key to Abbreviations:
TM Team **MK** Maker

6 When the data transfer has been completed successfully, choose *Exit* and press the SELECT Button. Choosing *Retry* will bring you back to the *Send Confirmation* menu.

Exit Menu

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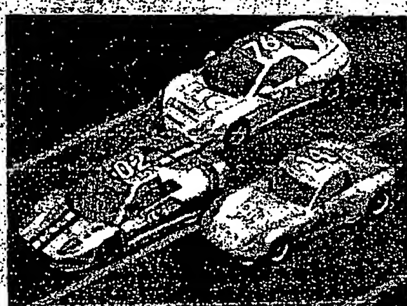
Receive Mode

This mode is used to receive car data sent in Send Mode.

1. Choose the *Receive* menu item from the *Send/Receive* menu and then press the SELECT Button. This will show the *Receive Start* menu. Press the SELECT Button to begin receiving data. The screen will show a message that it is receiving data.

2. When data transfer is completed, the *Receive Confirmation* menu is shown. Press the SELECT Button to return to the Title Screen to leave Receive Mode. If any data transfer errors occur, or if there is no data input for a specified length of time, a data reception error will occur. When this happens, you will be returned to the Title Screen.



SEND
▸RECEIVE
EXIT

Send / Receive Menu

PRESS↵
▾
SEND
TRANSFER

Receive Start Menu

TRANSFER
COMPLETE

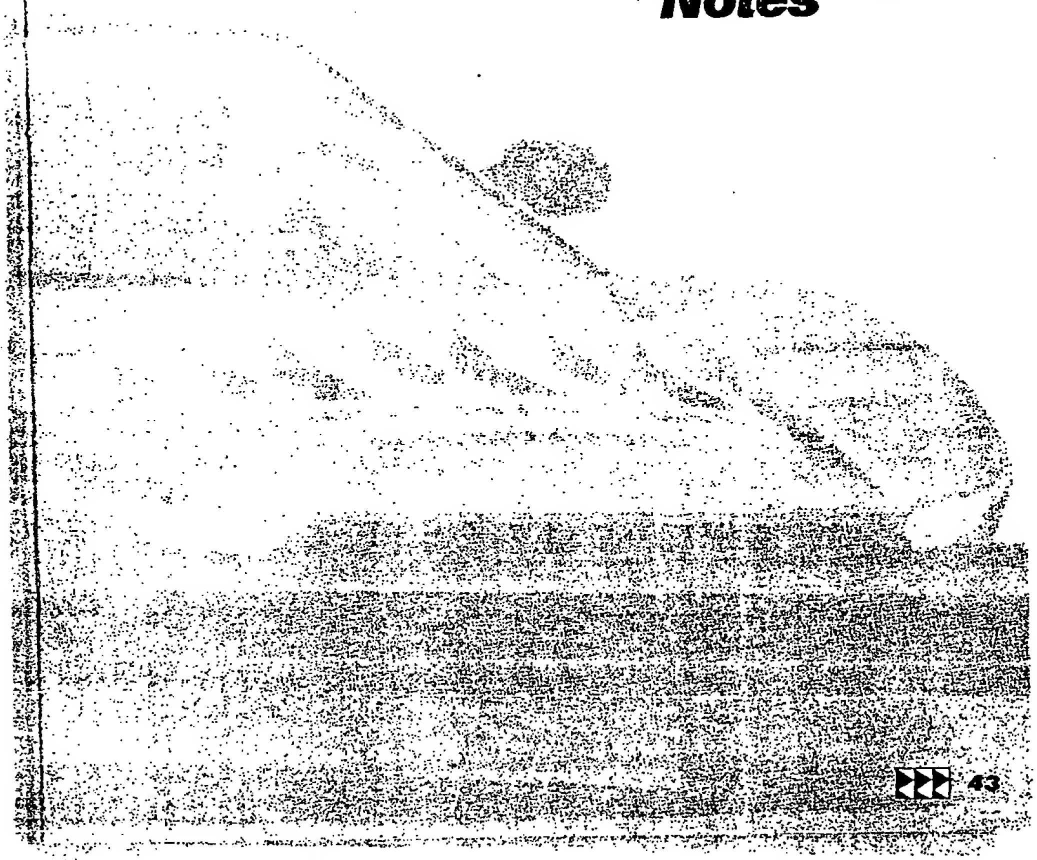
Transfer Complete Screen

TM: MMM
MK: AST
CAR No 1
PRESS↵

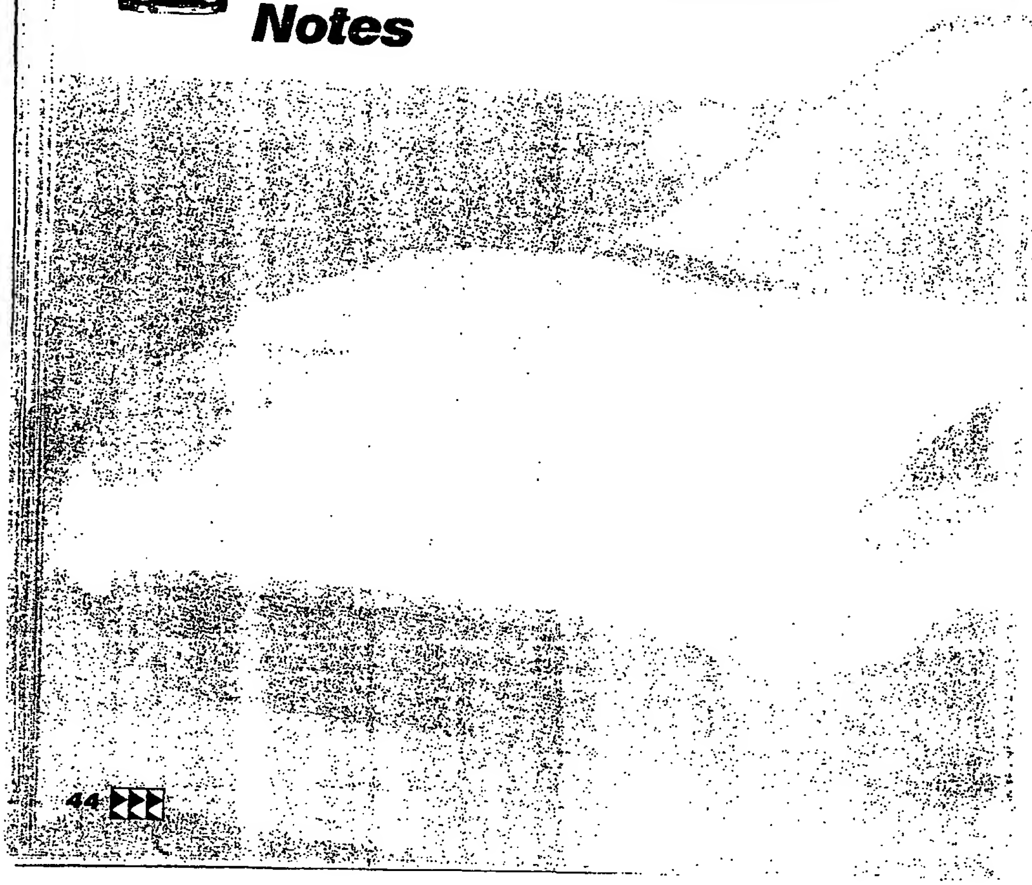
Receive Confirmation Menu

NAA00005168

Notes



Notes



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	Tak Hyodo		
	Osamu Shibamiya		
Lead Tester:	Steve Peck		
Assistant Lead Tester:	Ed Chennault		

For questions and information not listed on the 900 line, write to:
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PlayStation

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Zenith Z-Star EX with J-Mouse Keyboard

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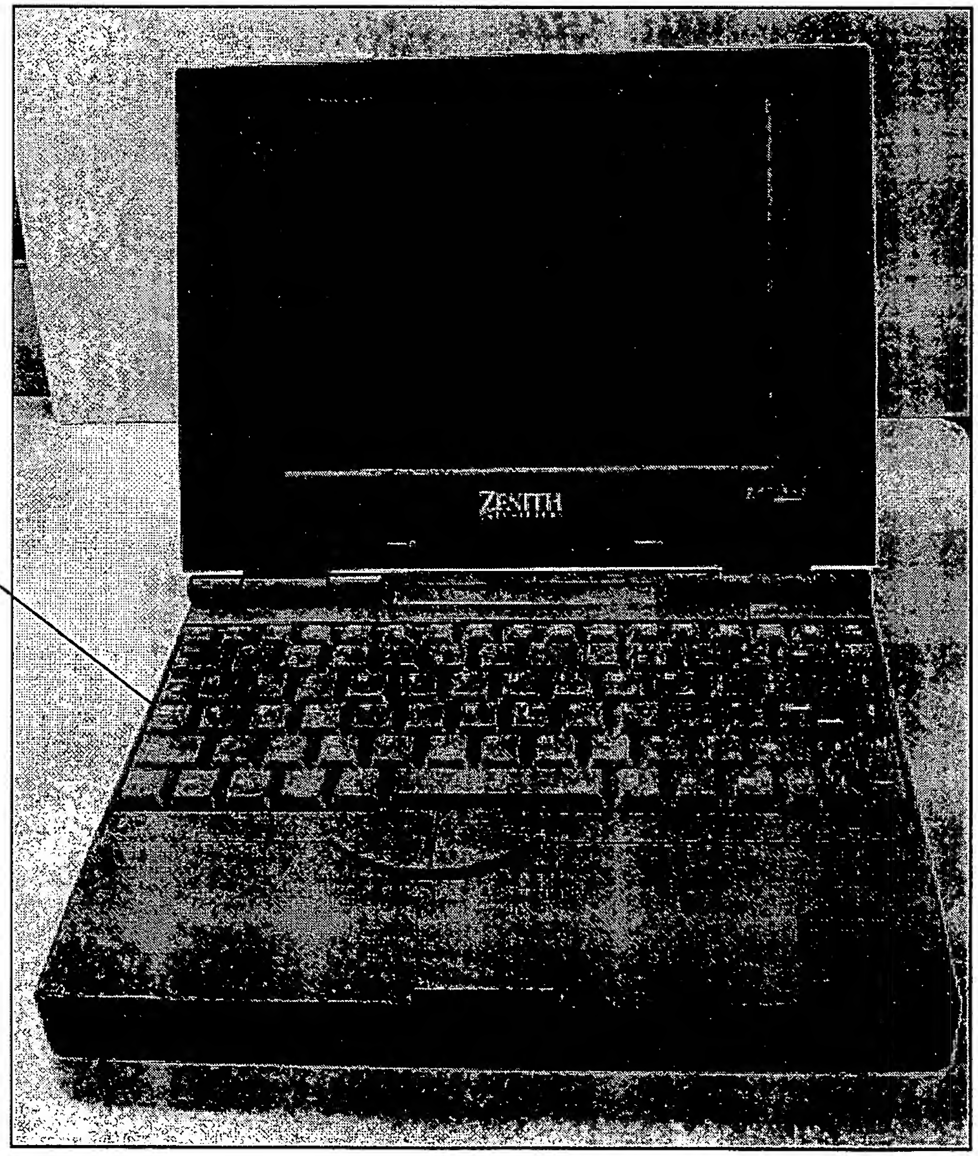
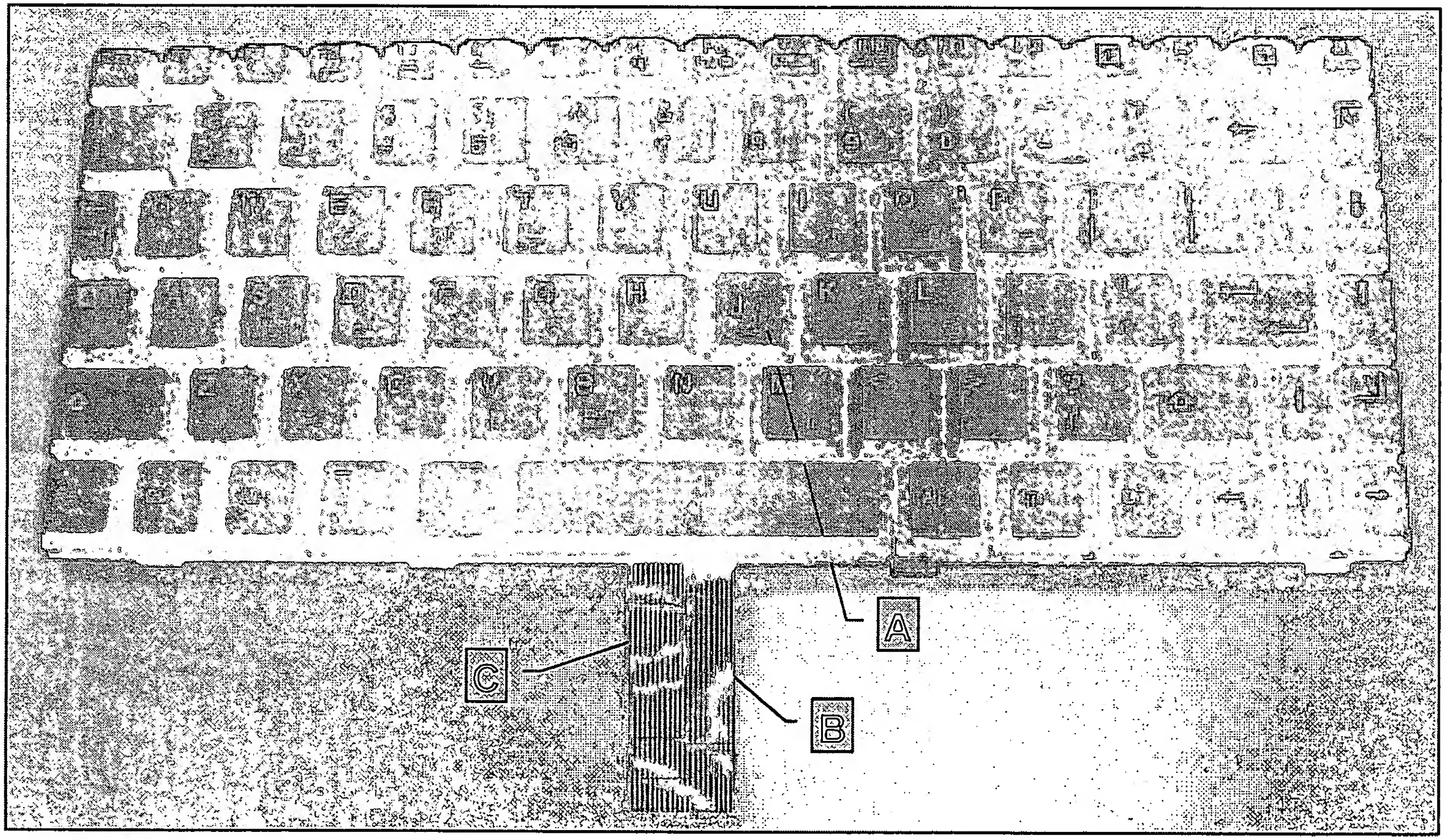


Zenith Z-Star EX with J-Mouse Keyboard



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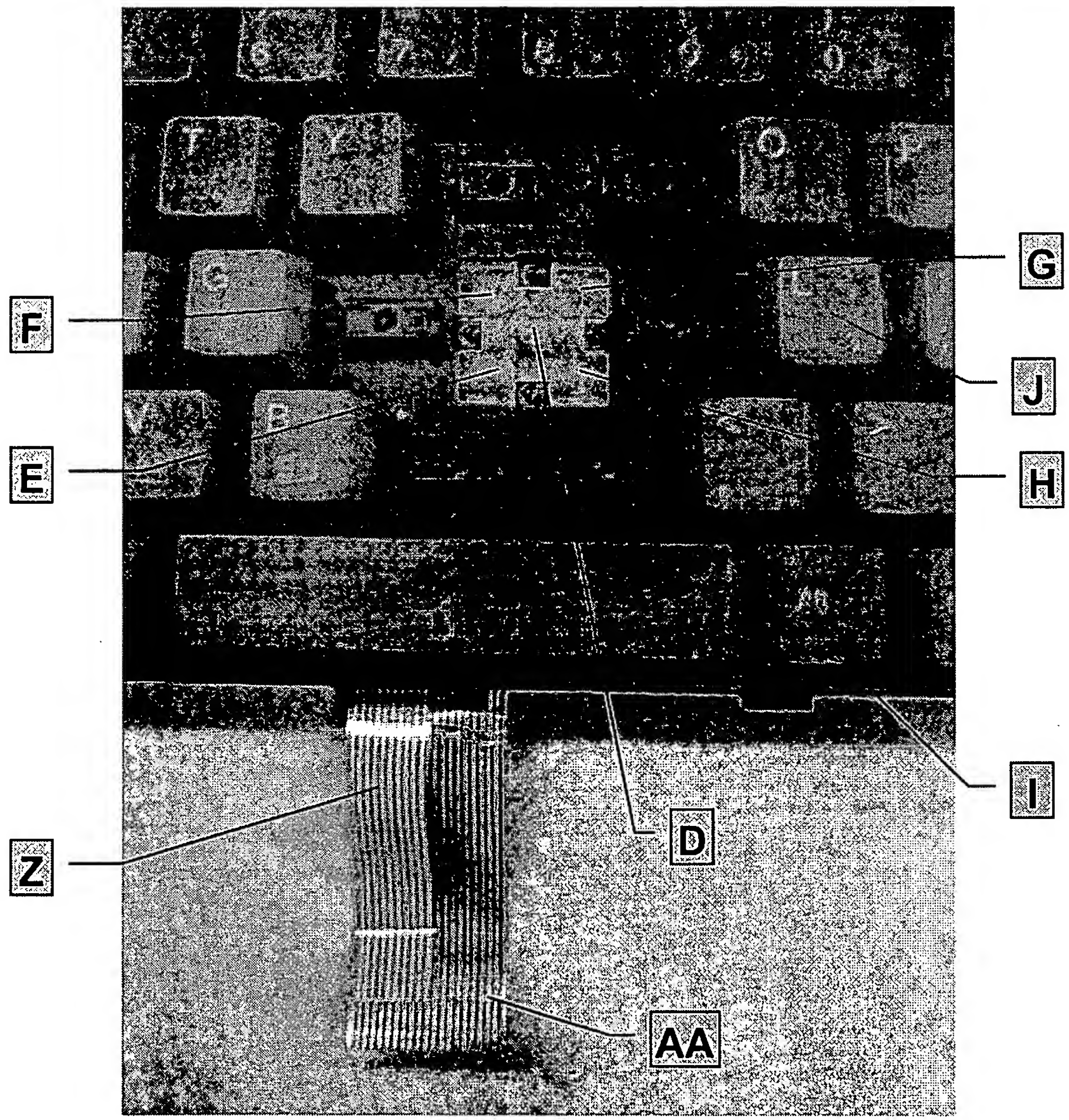

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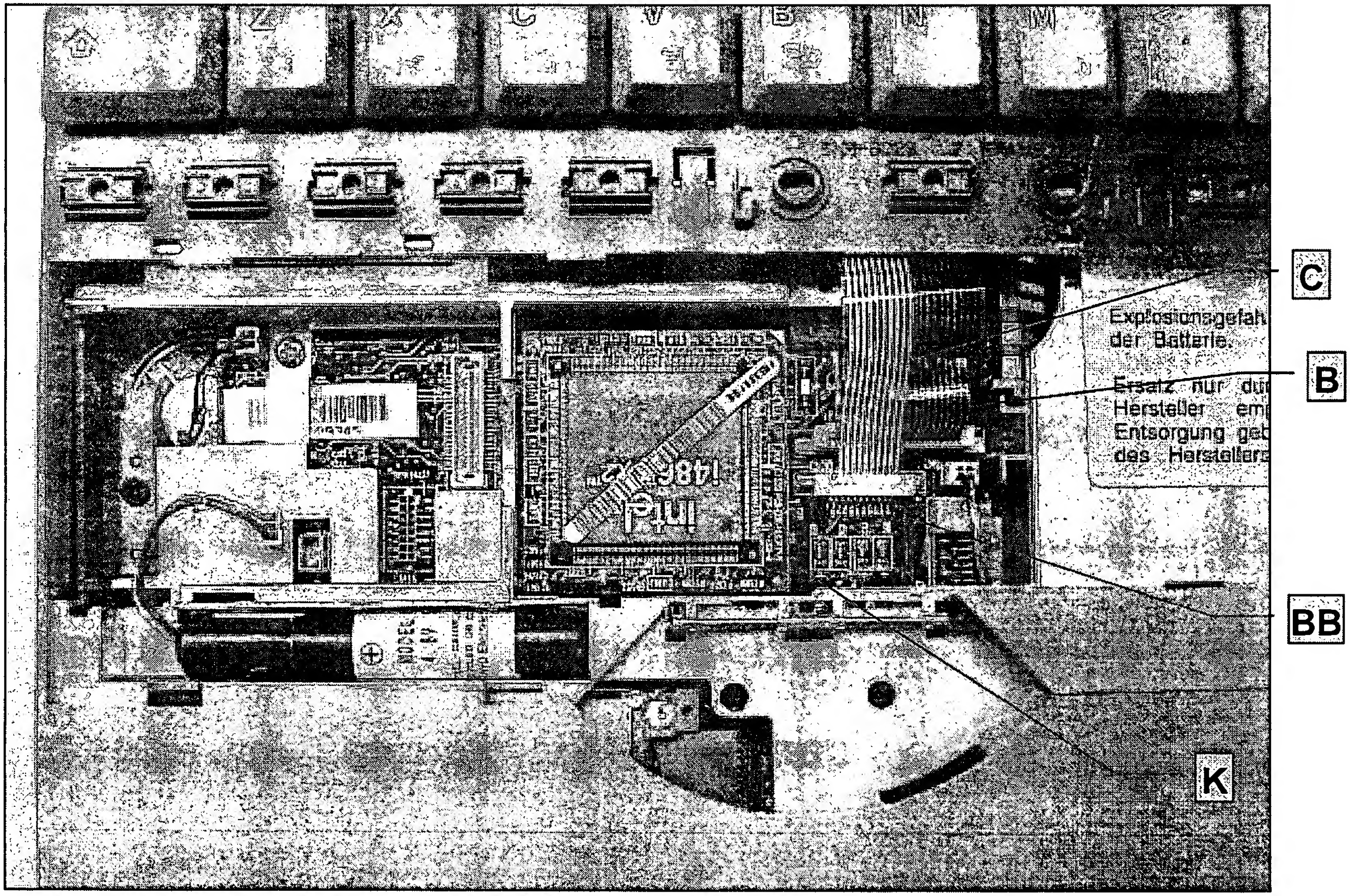

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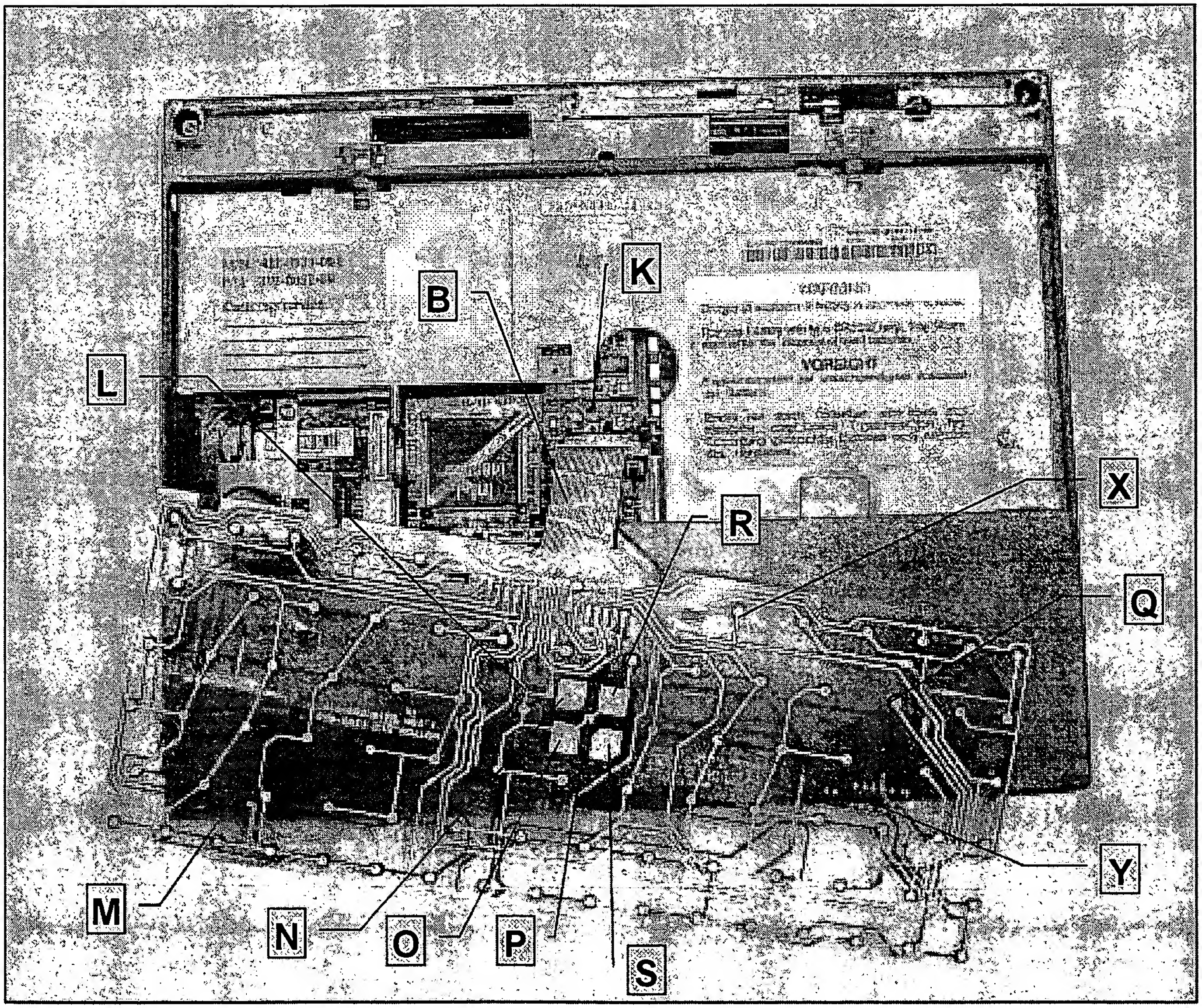

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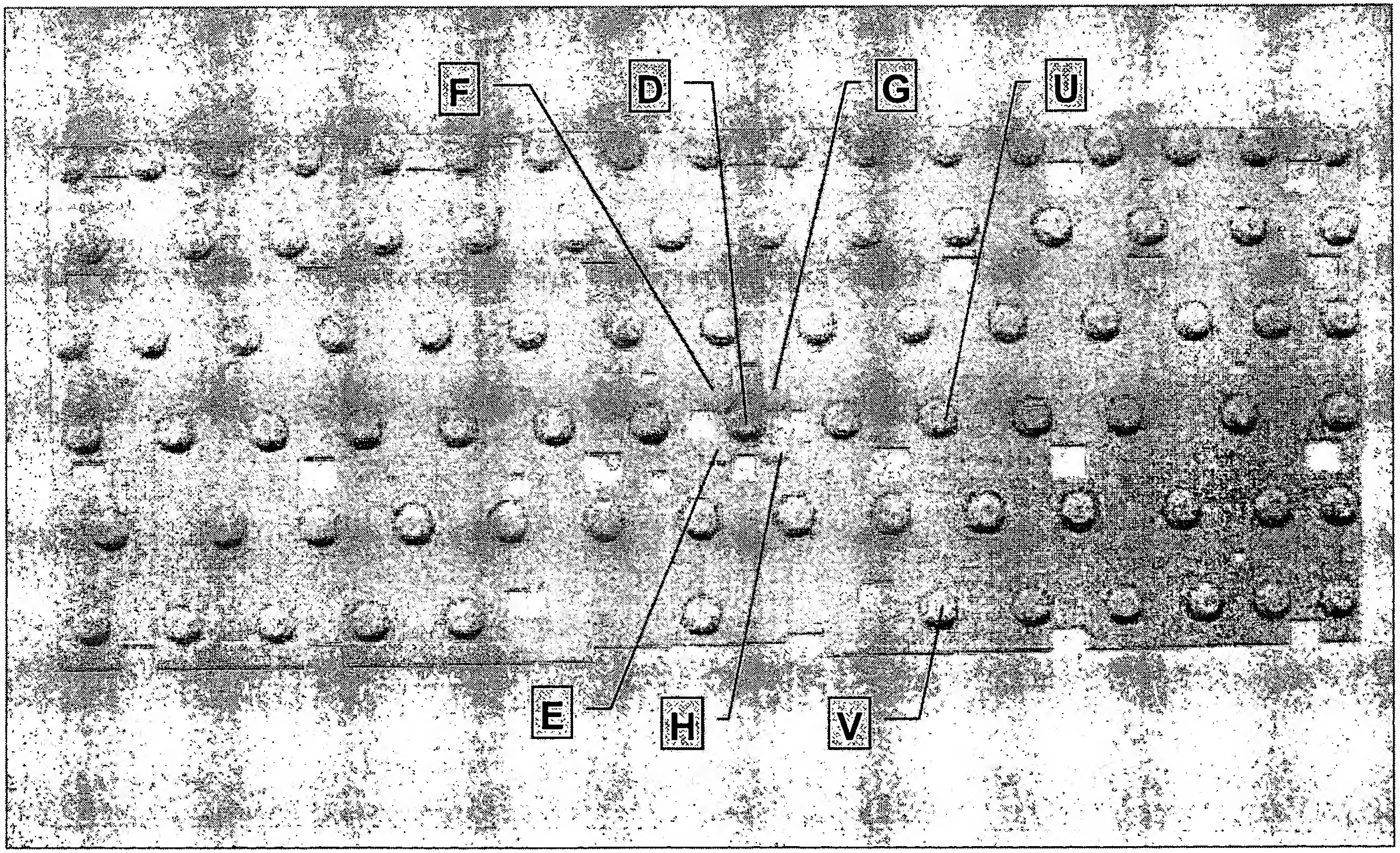

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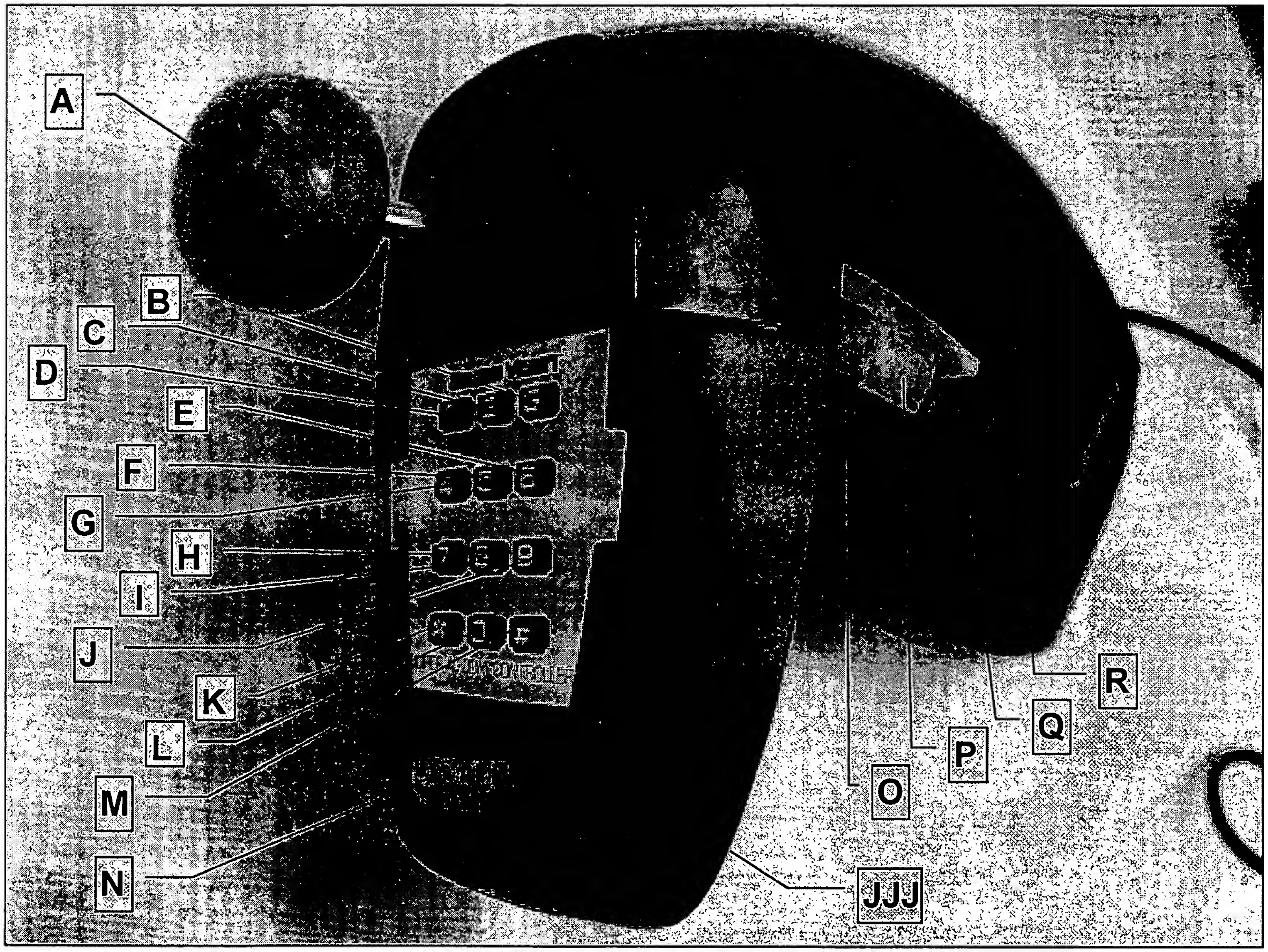

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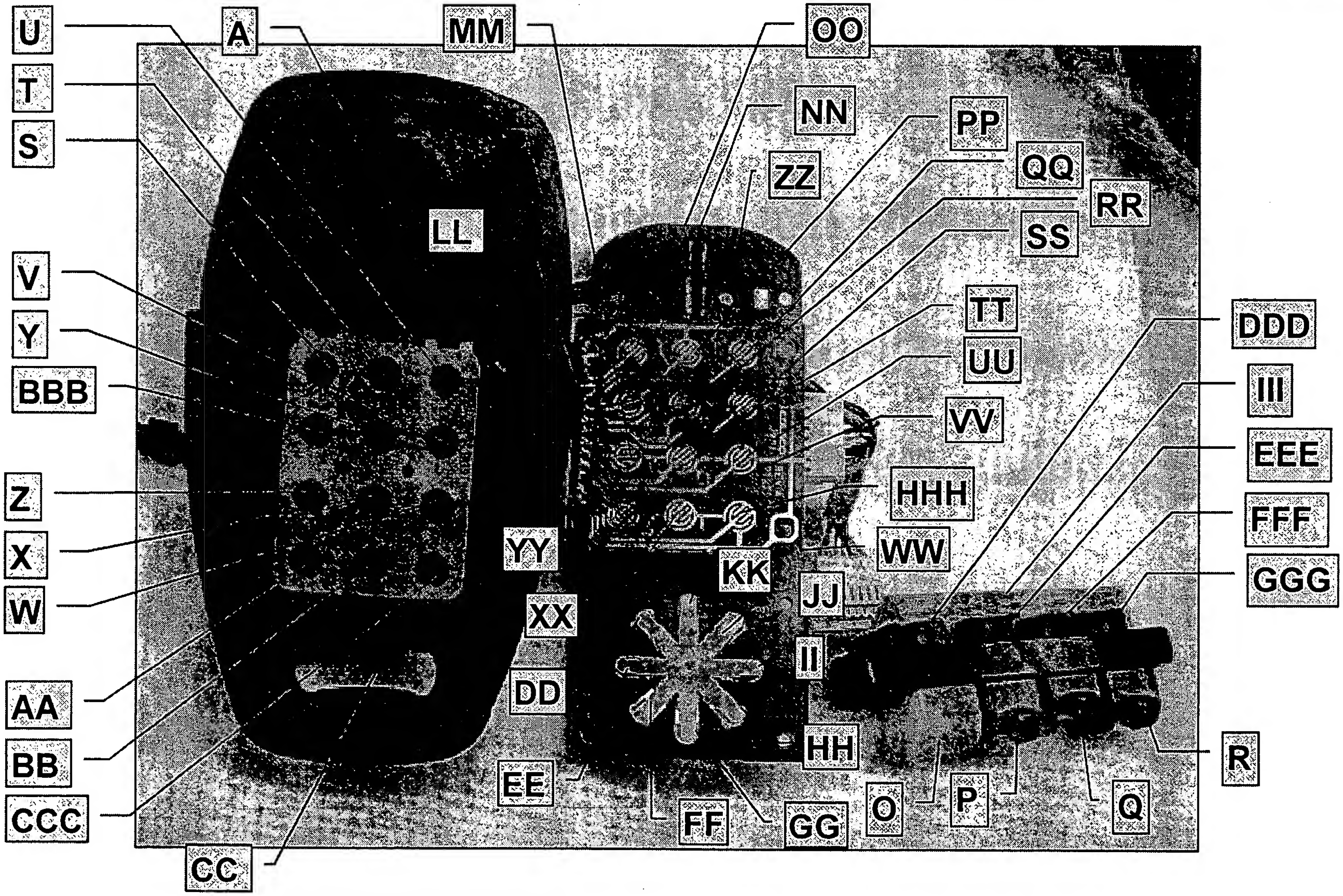

ColecoVision-Super Action Controller

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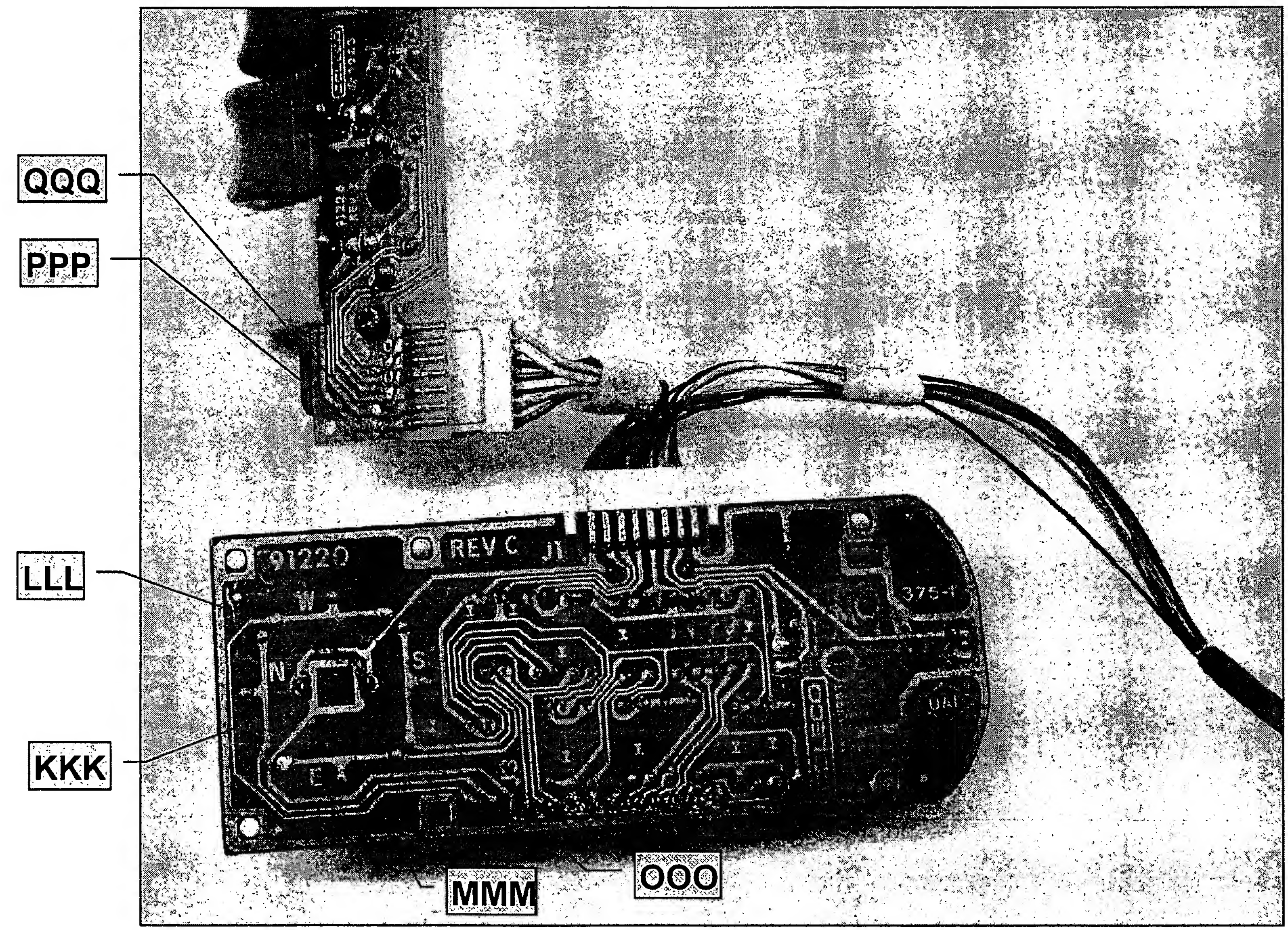

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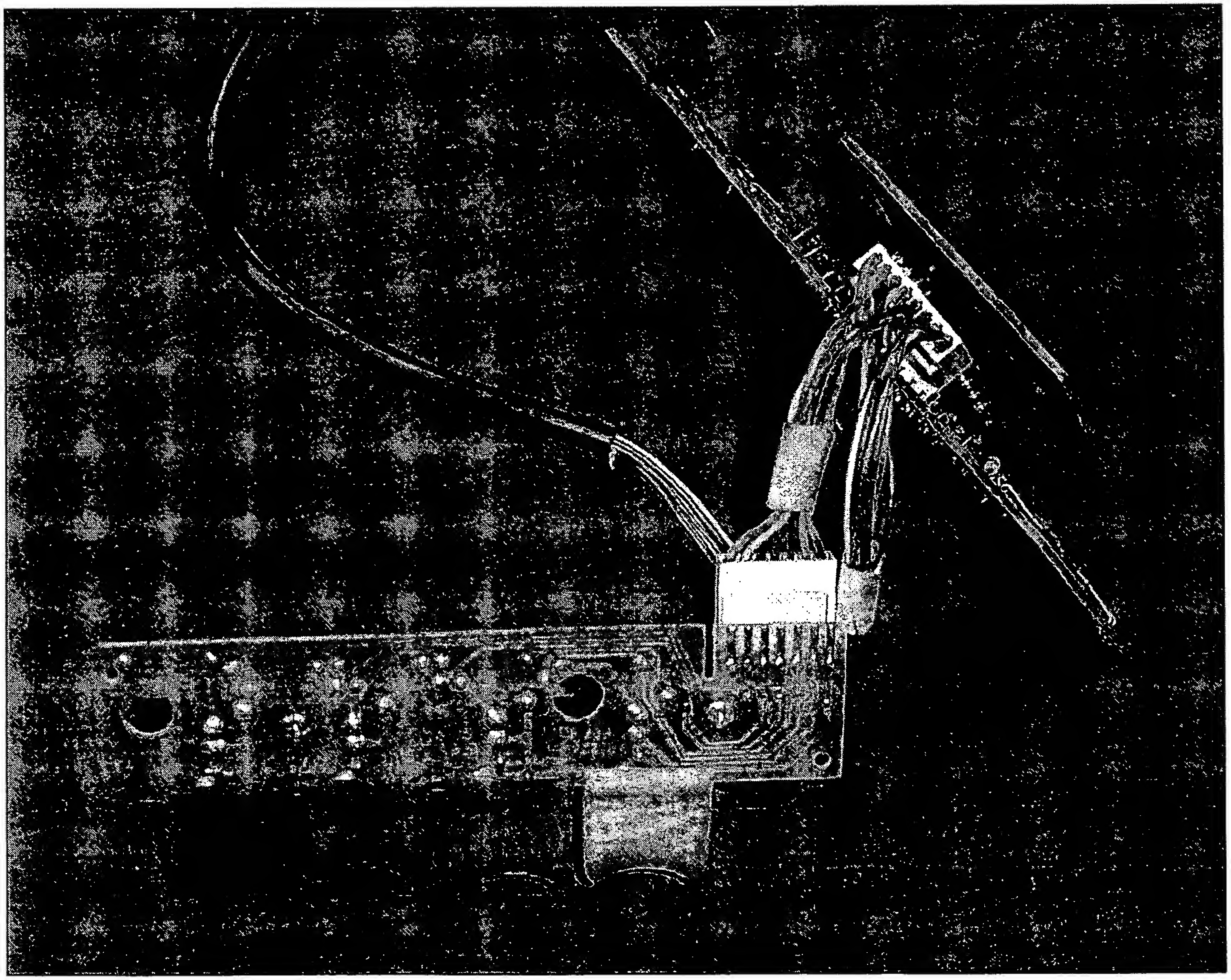

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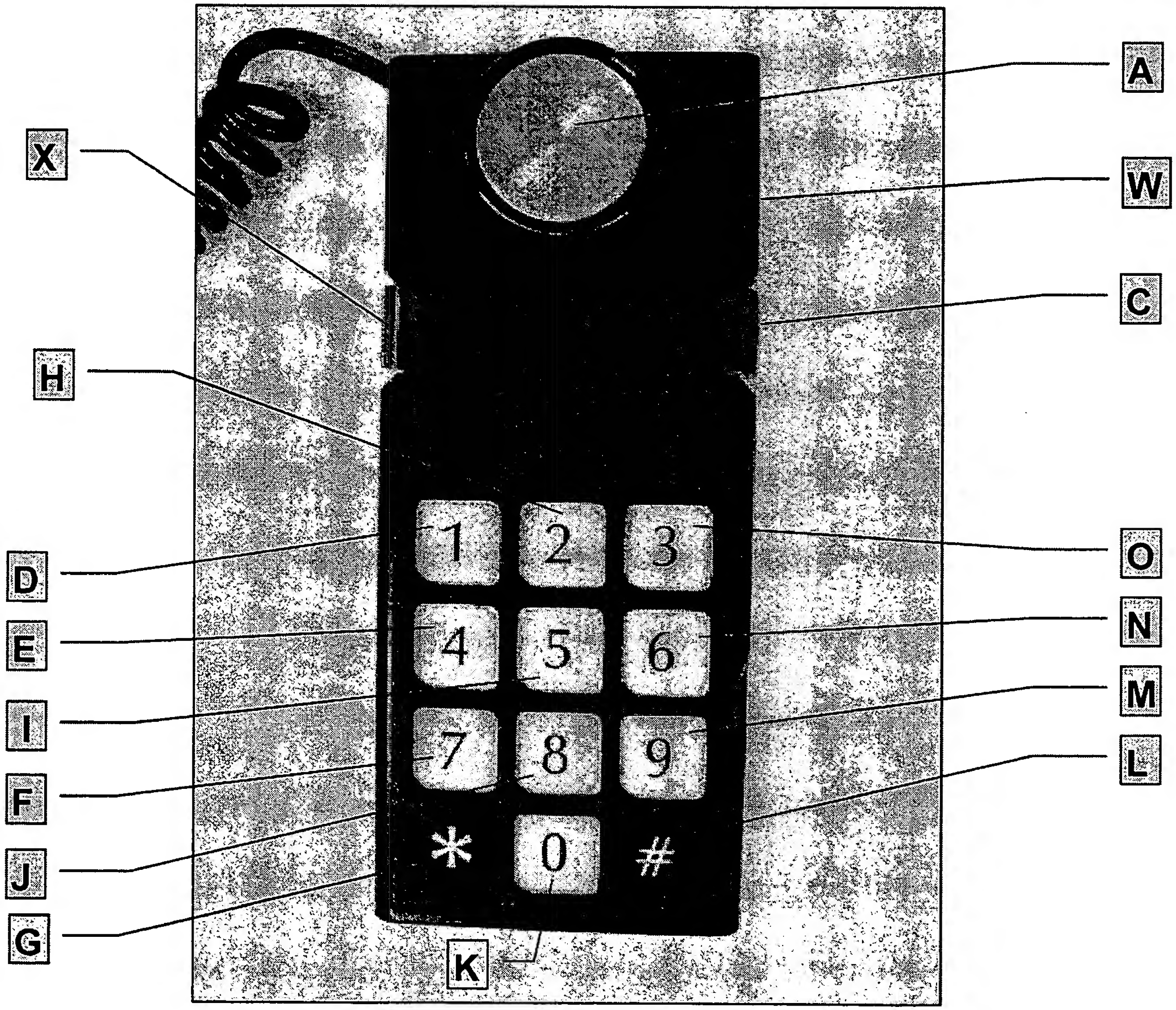

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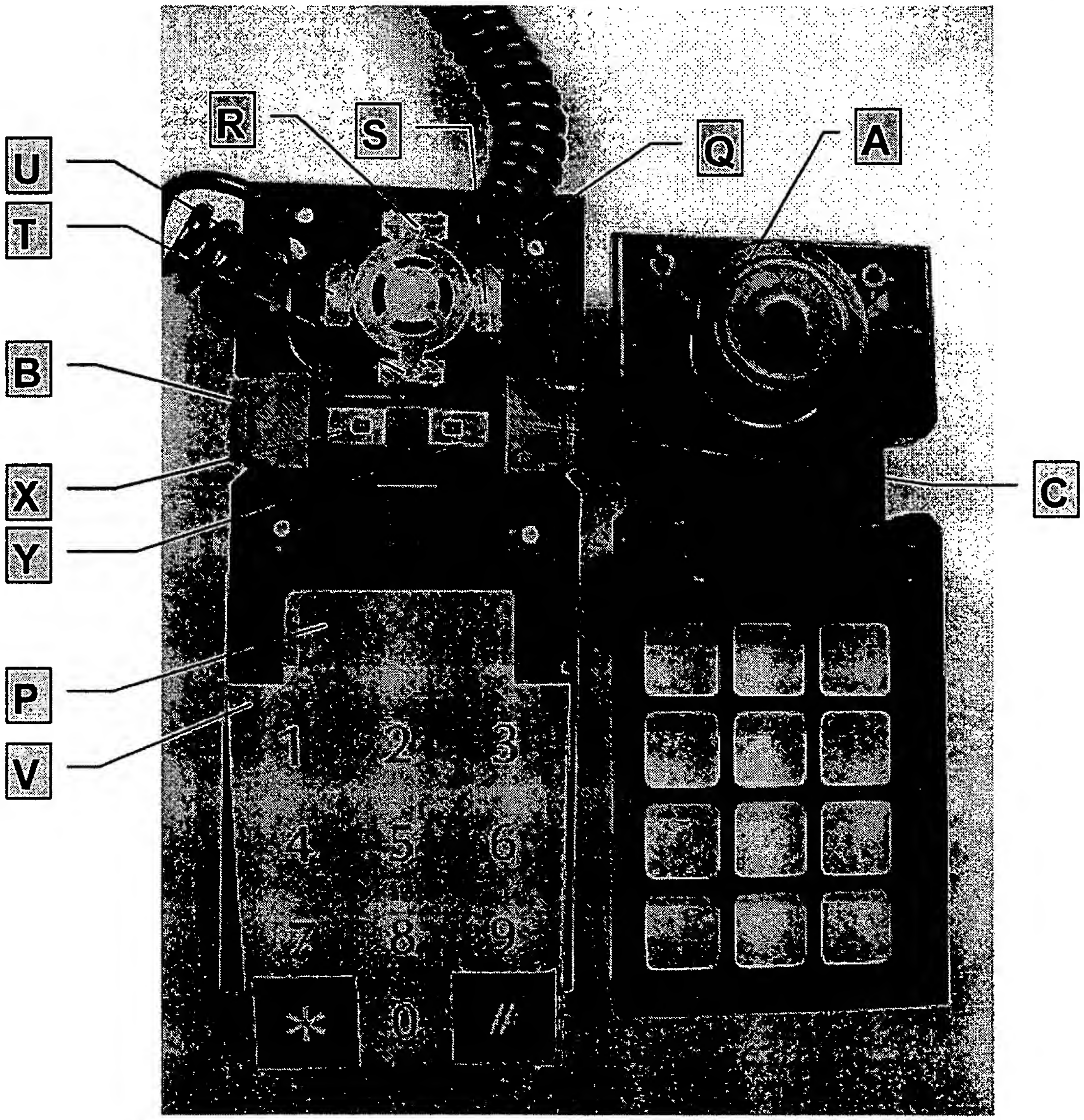

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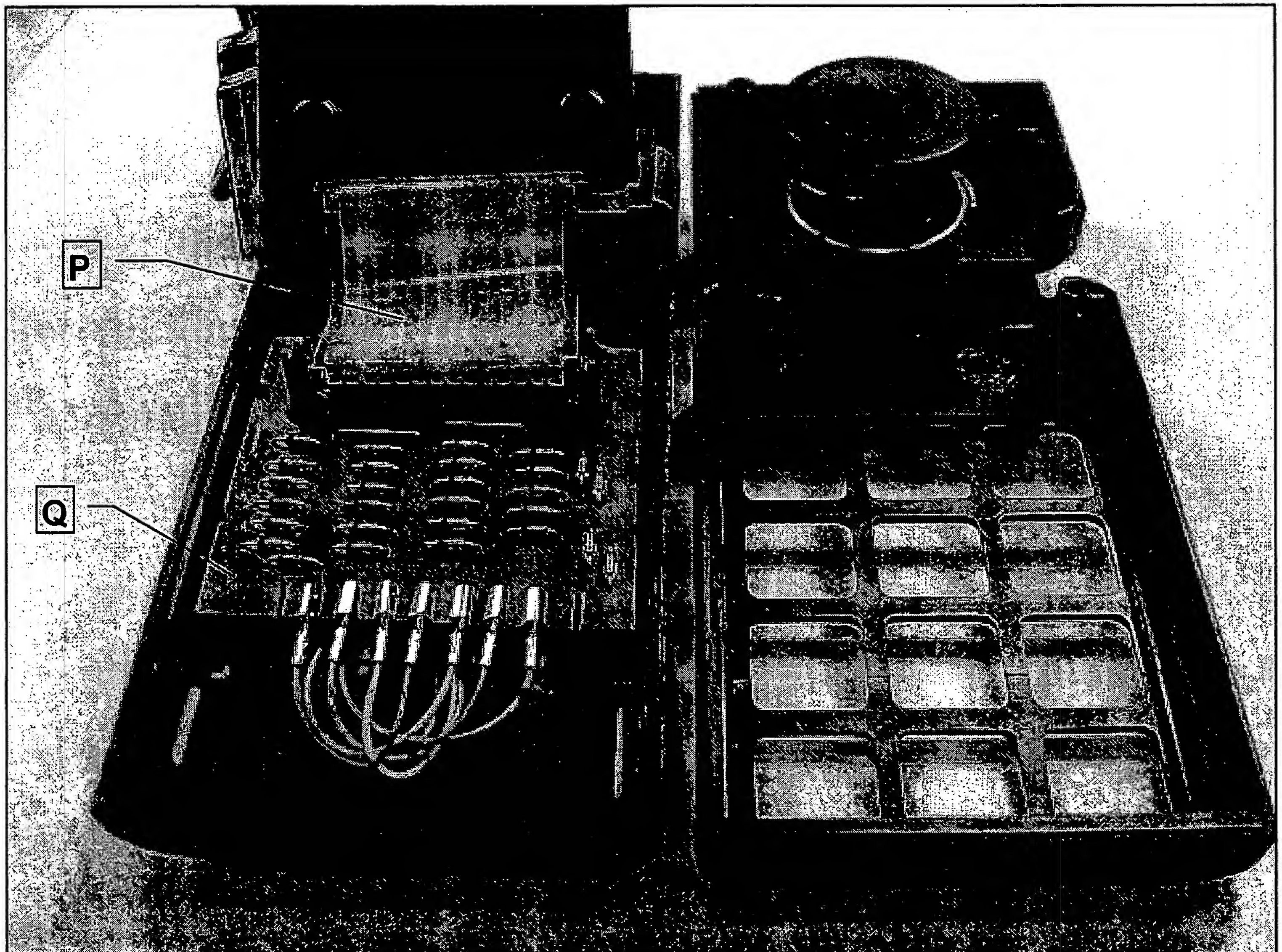

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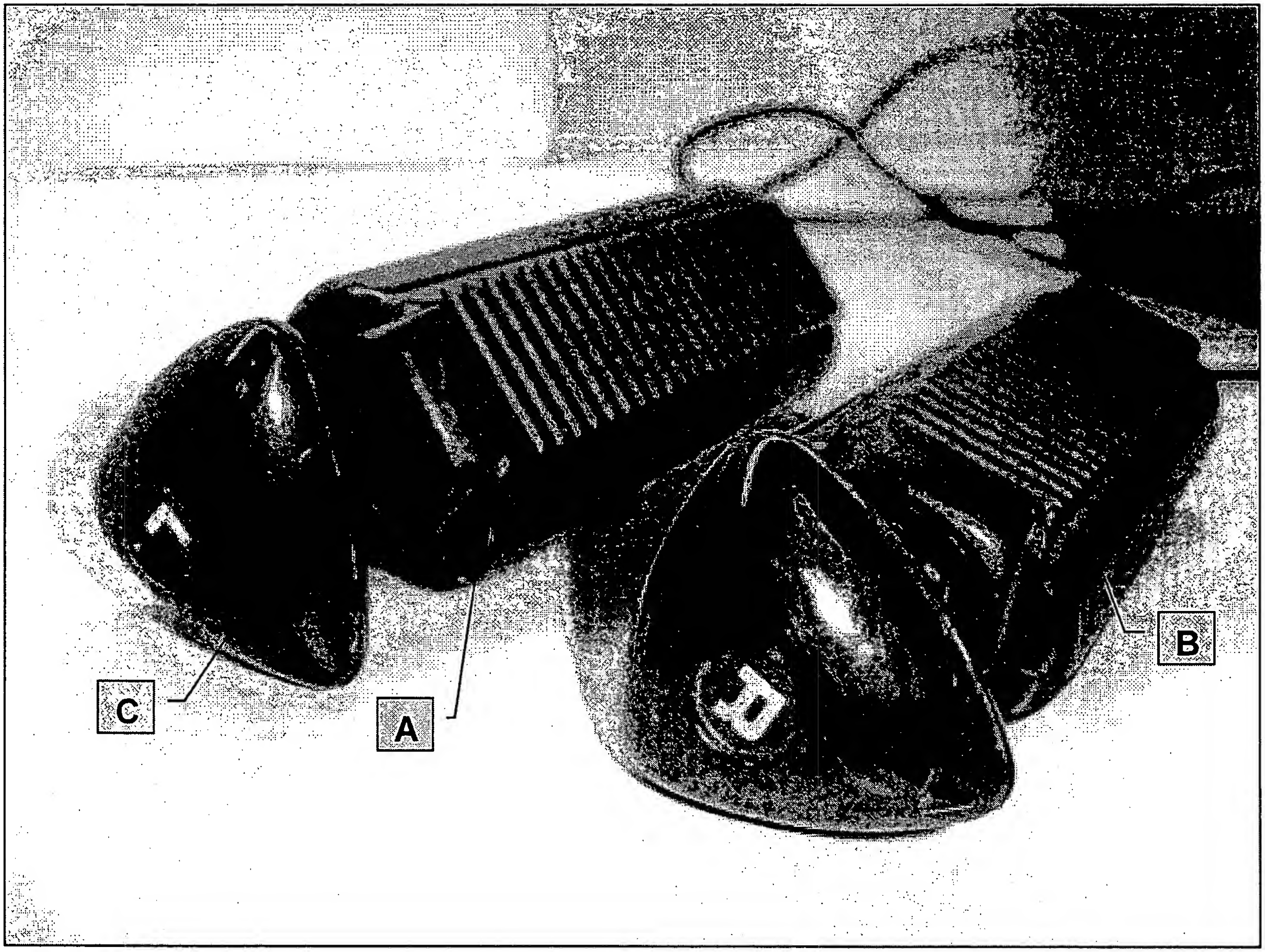

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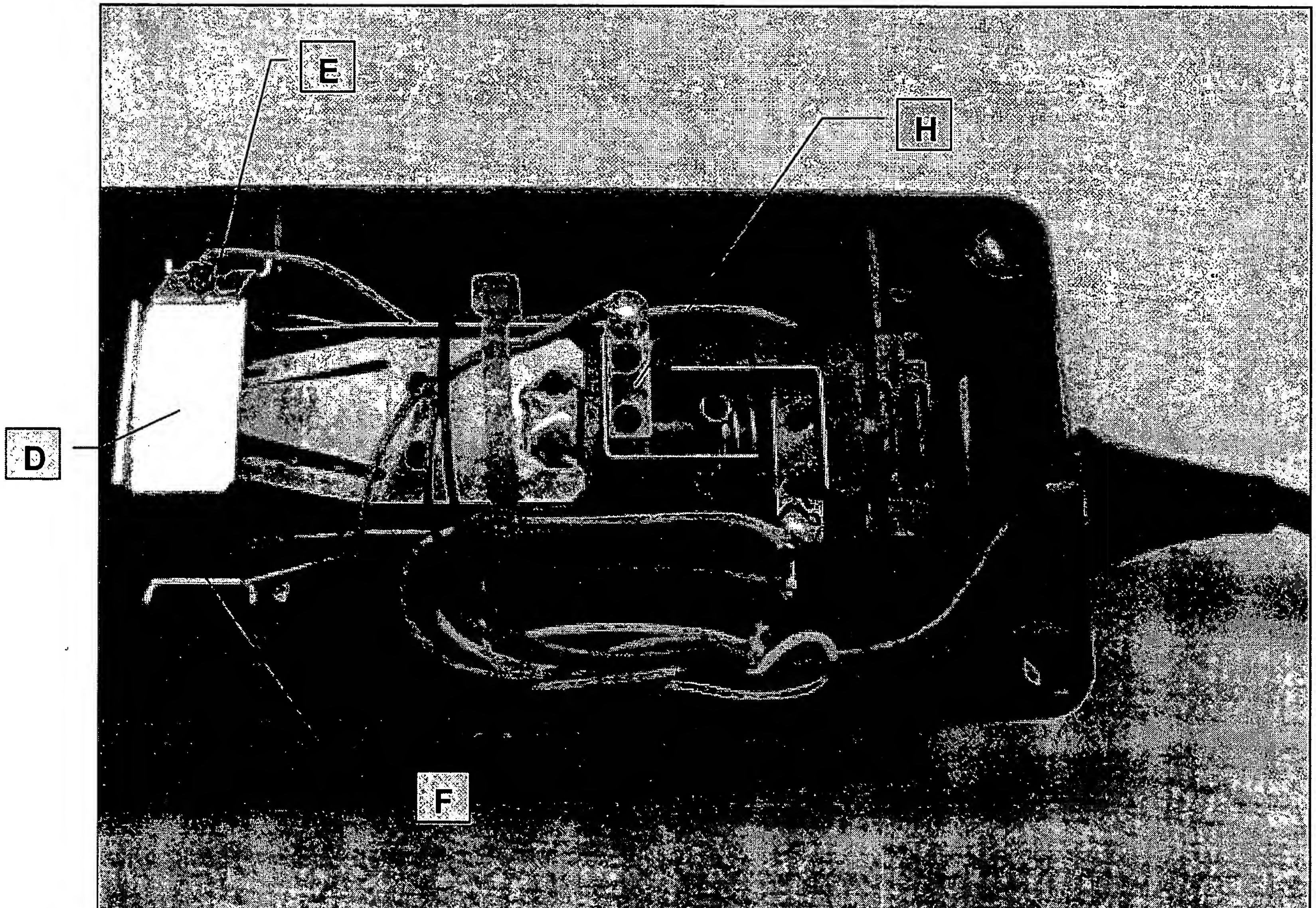

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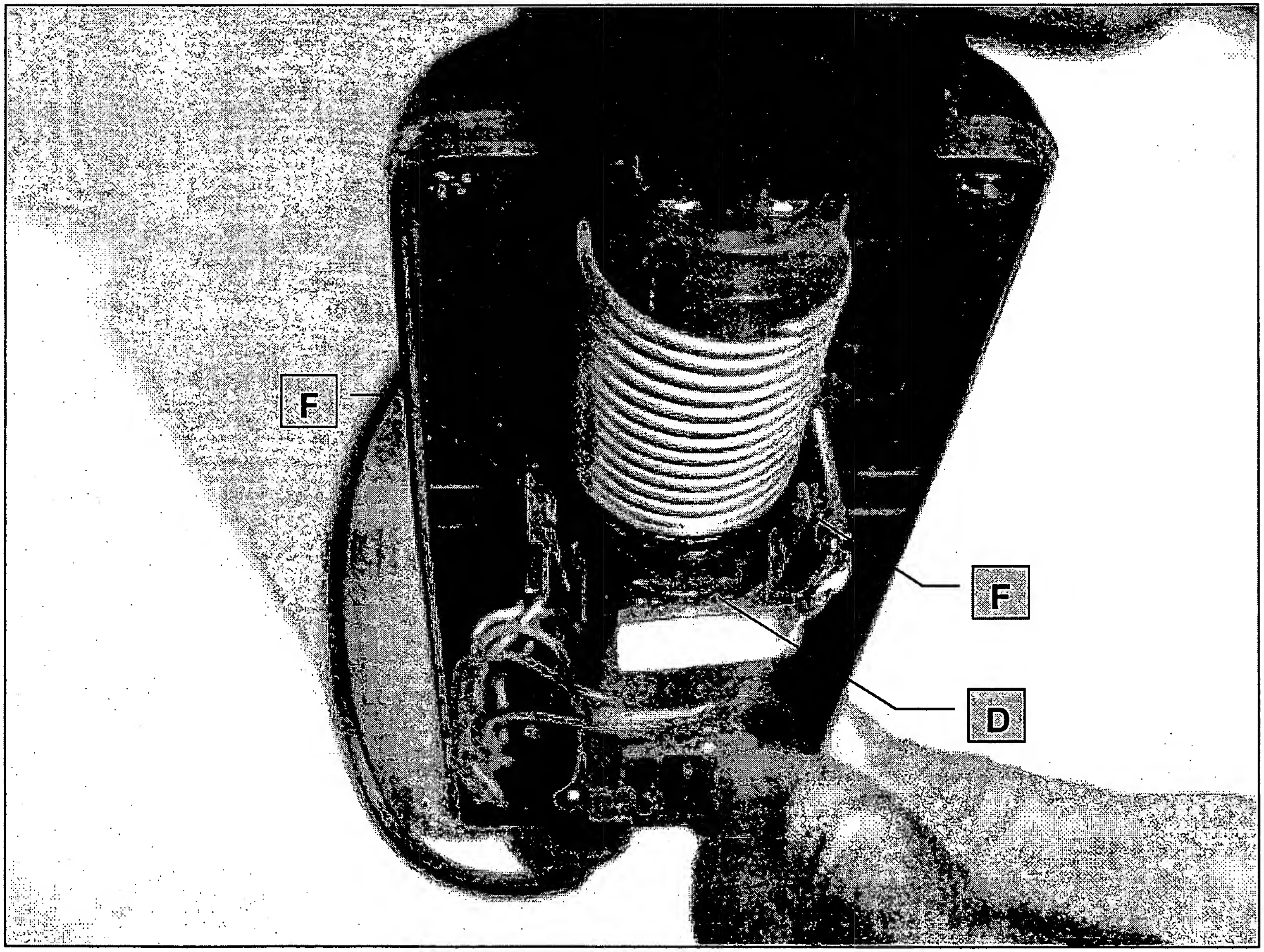

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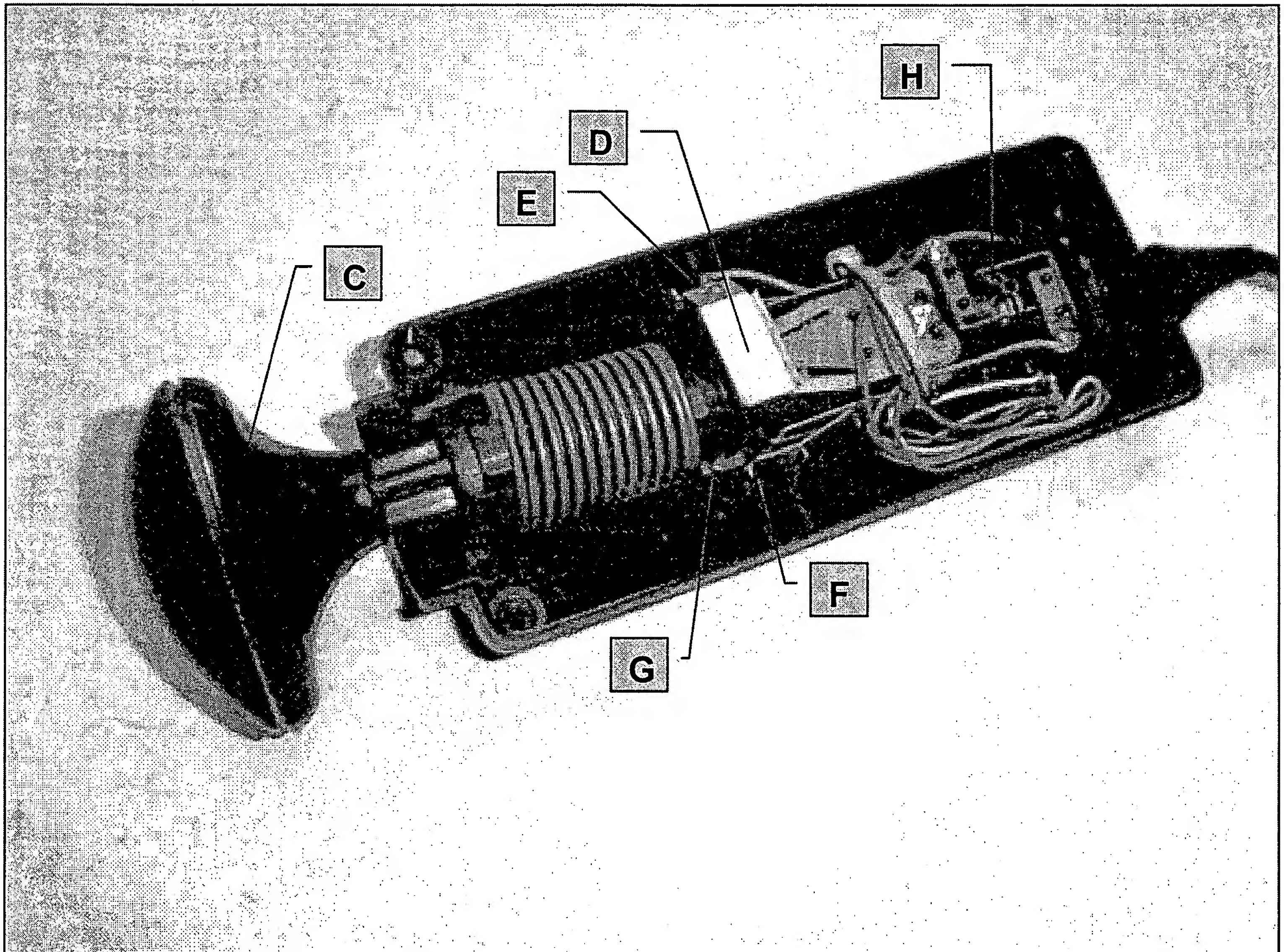

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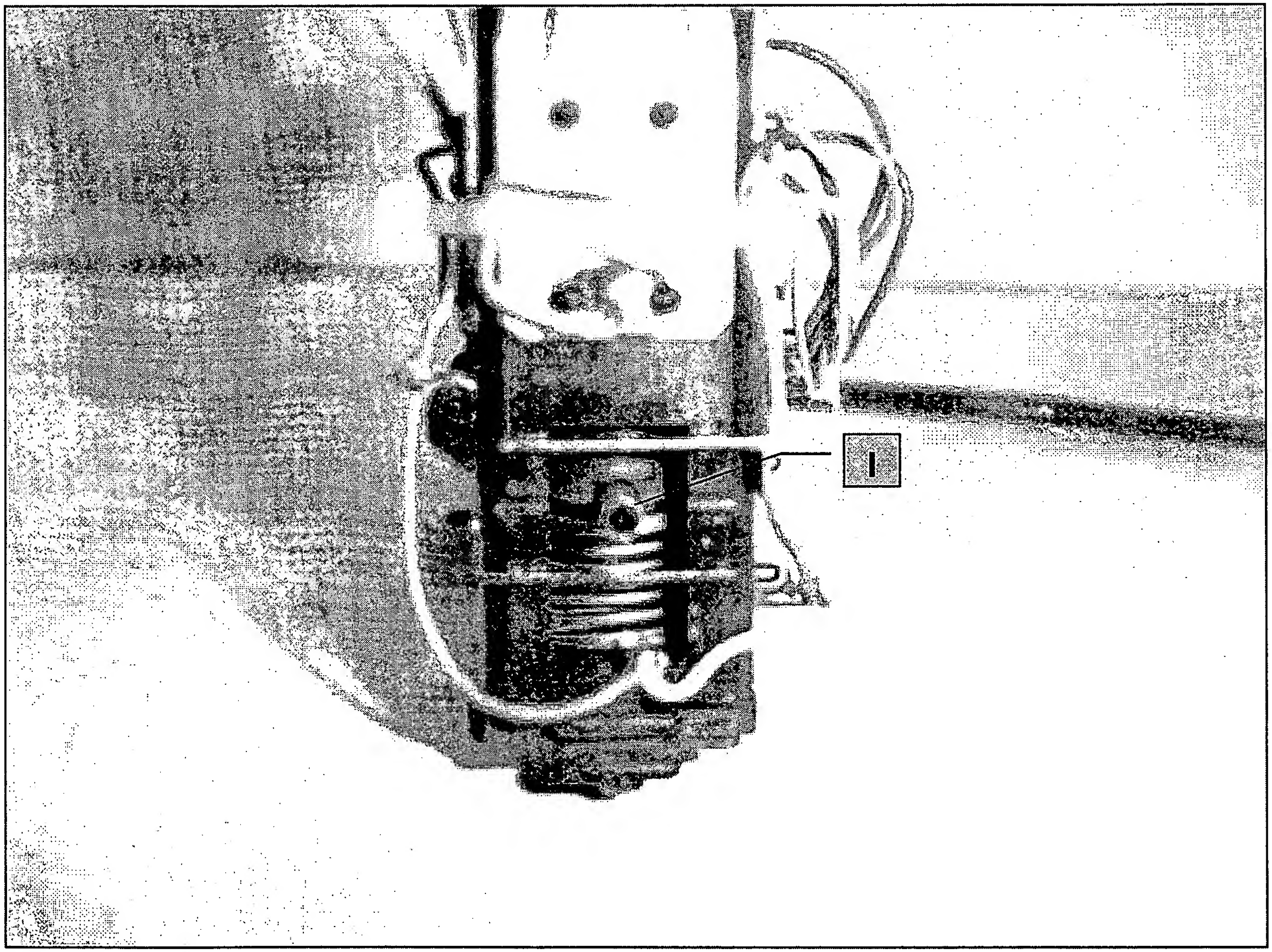

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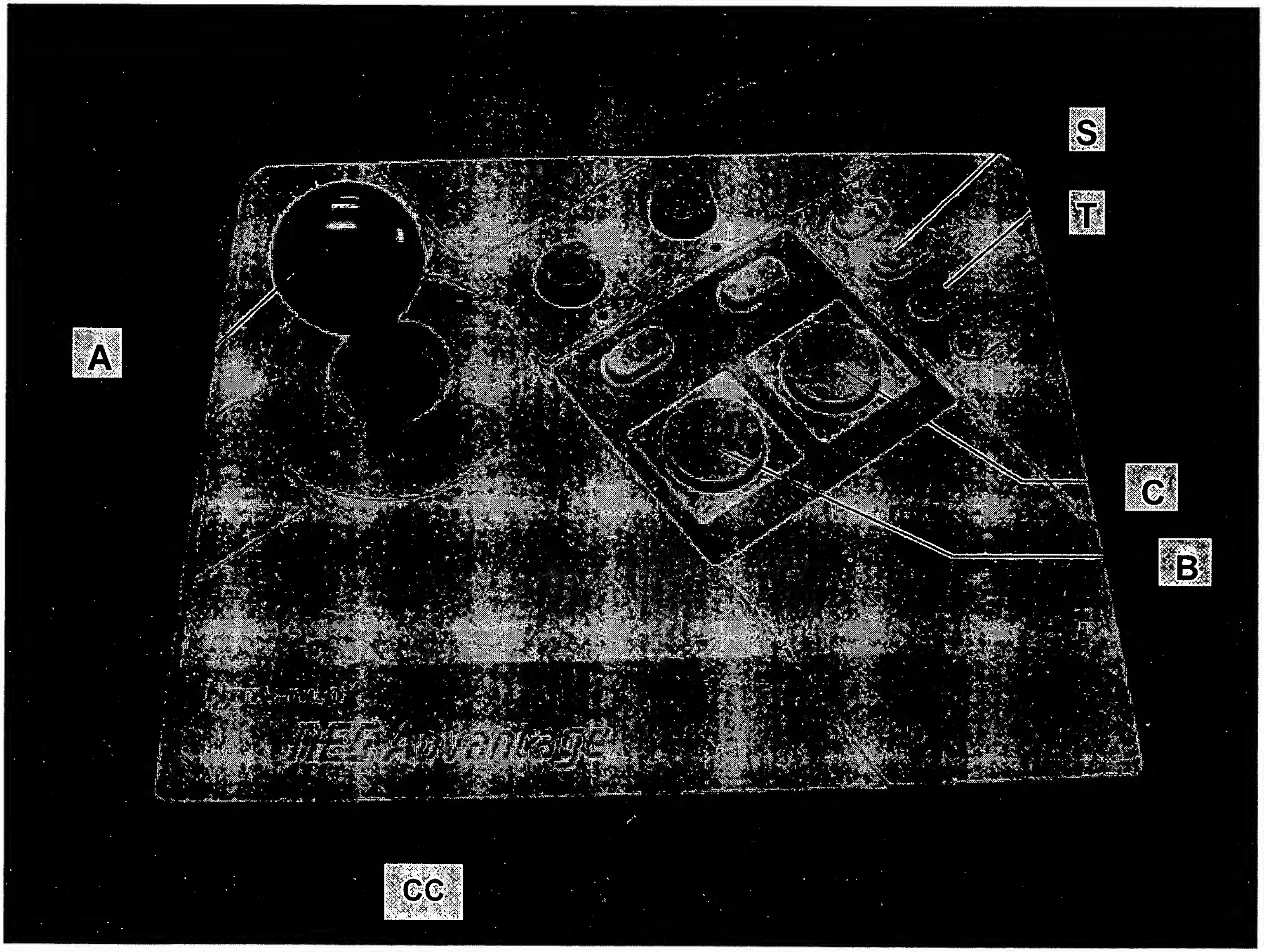

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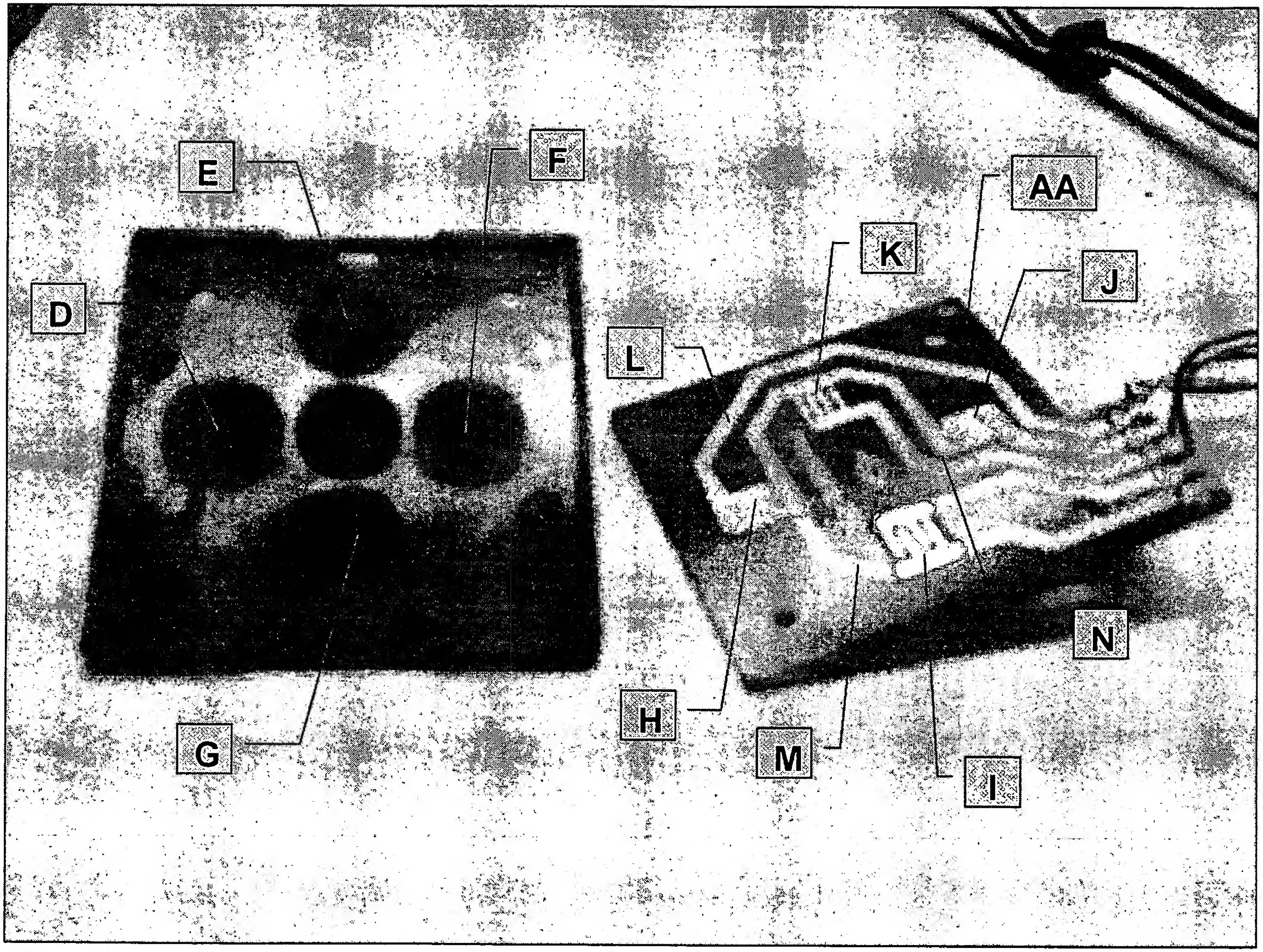

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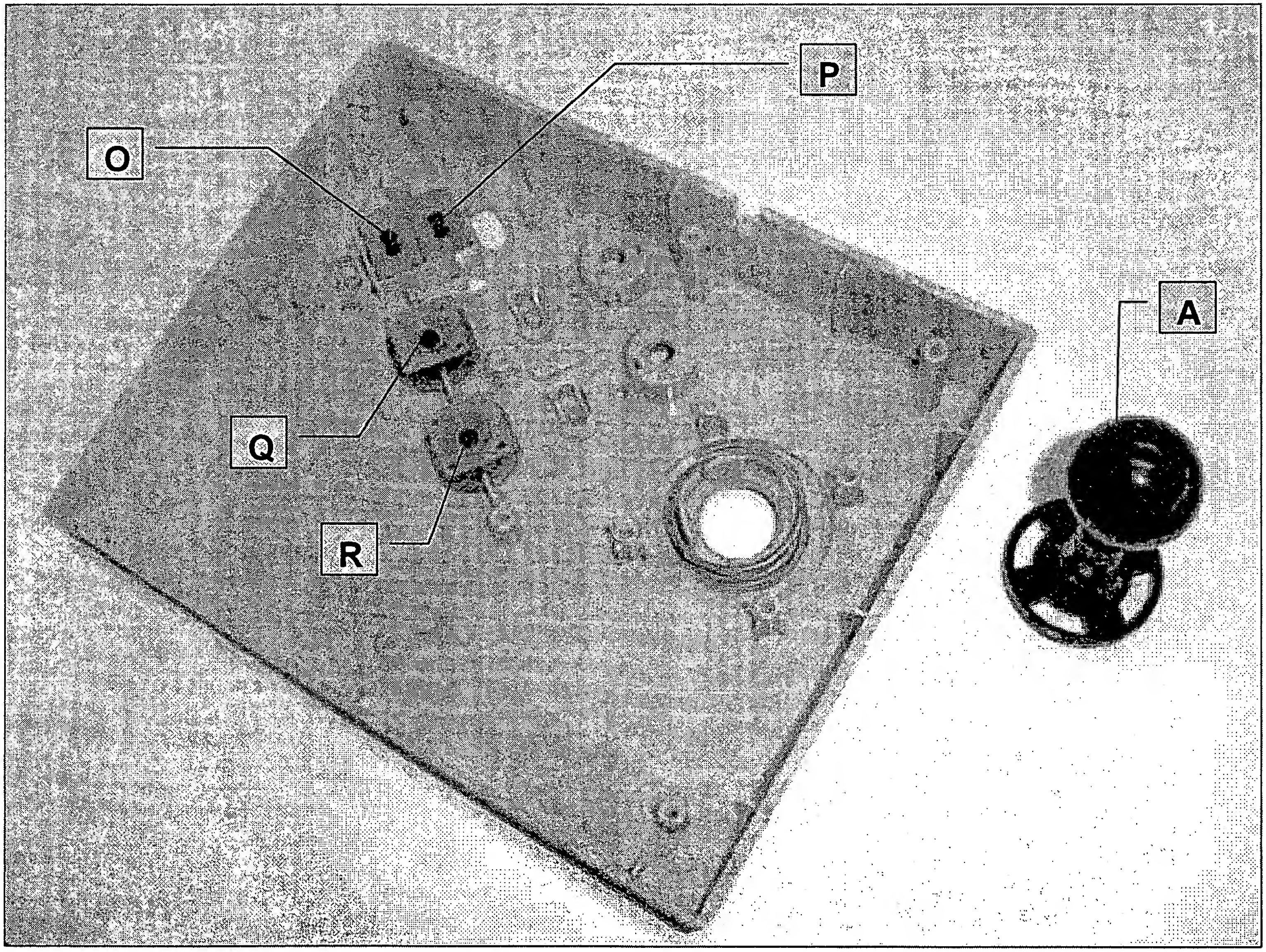

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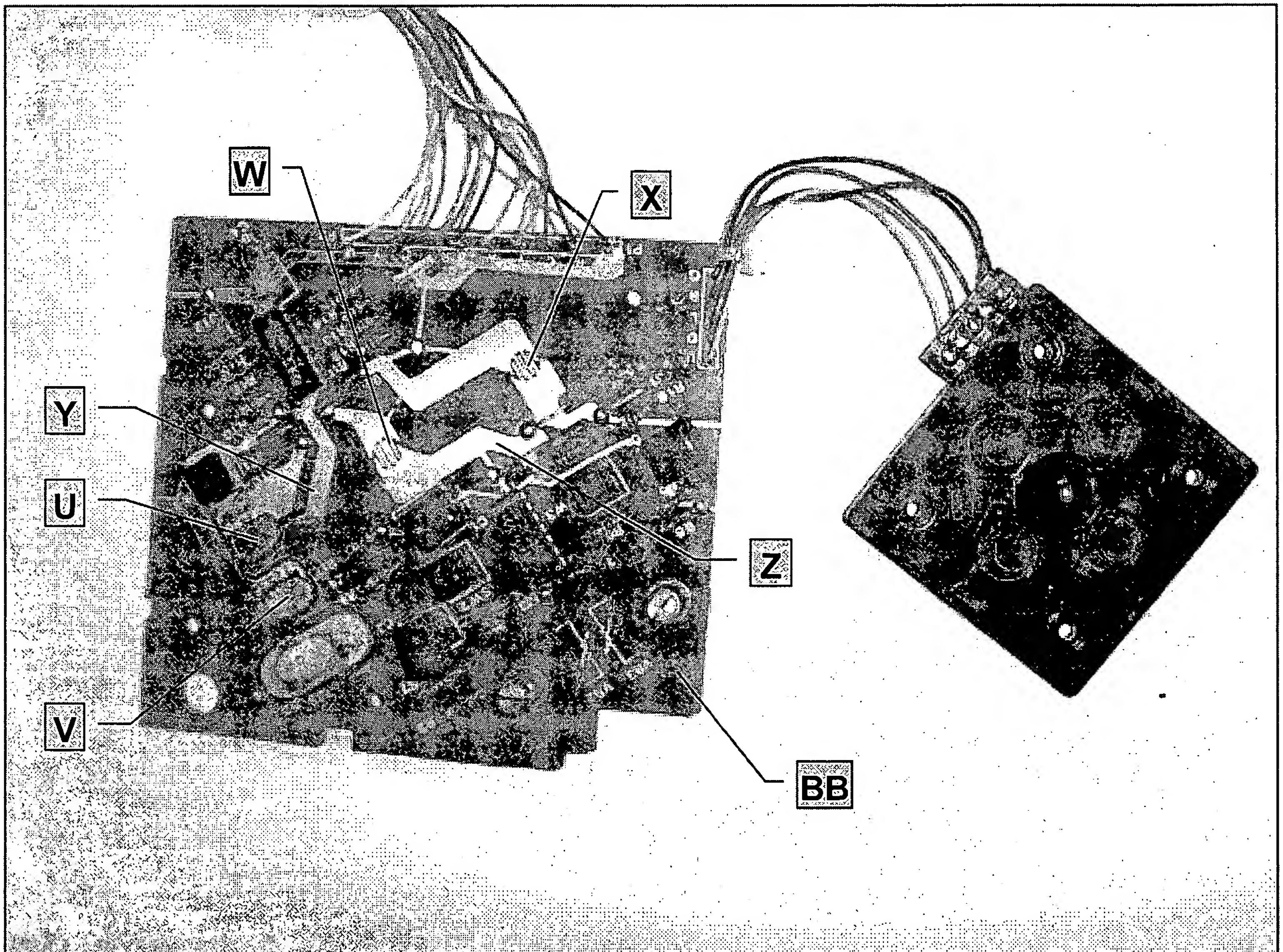

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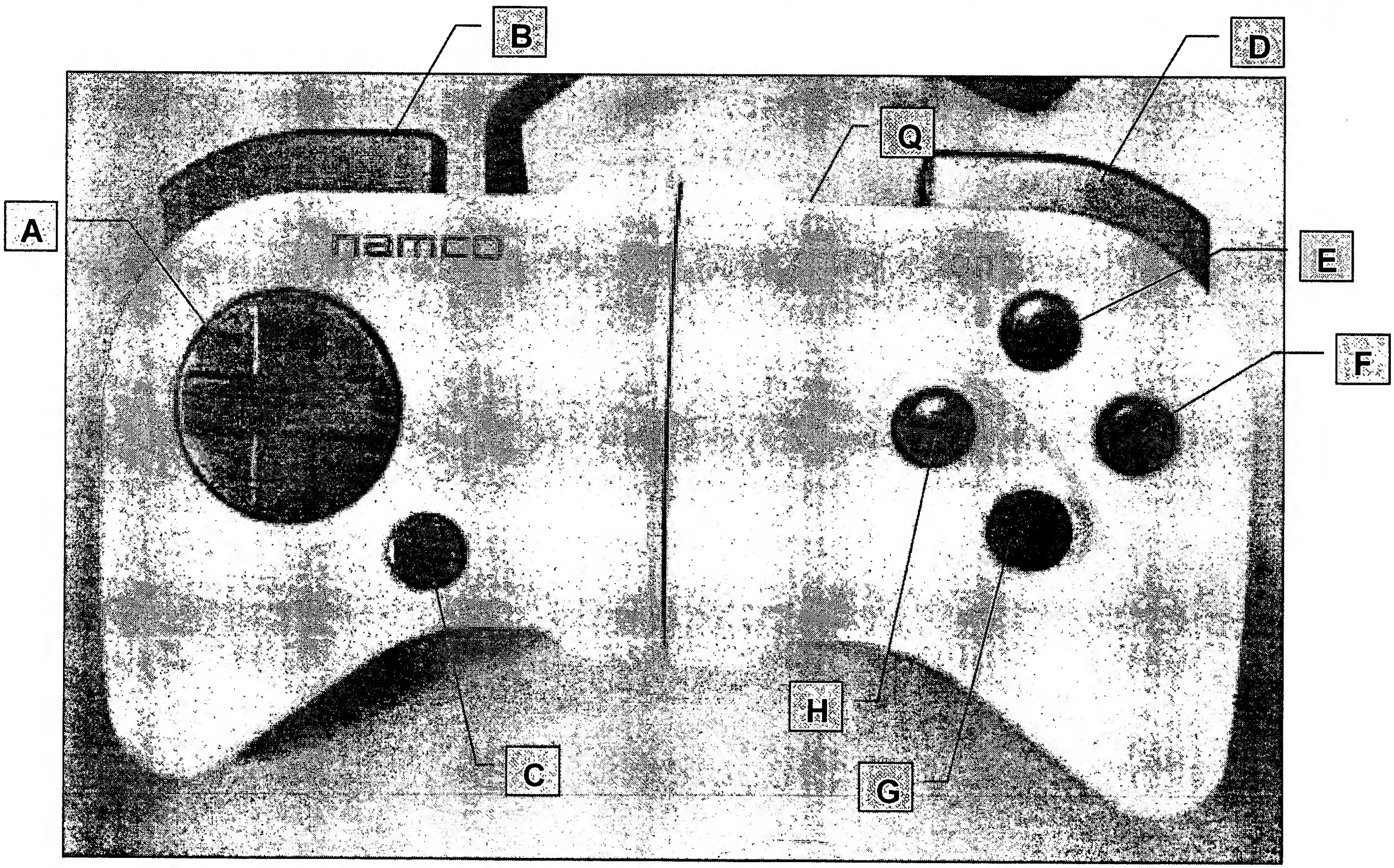

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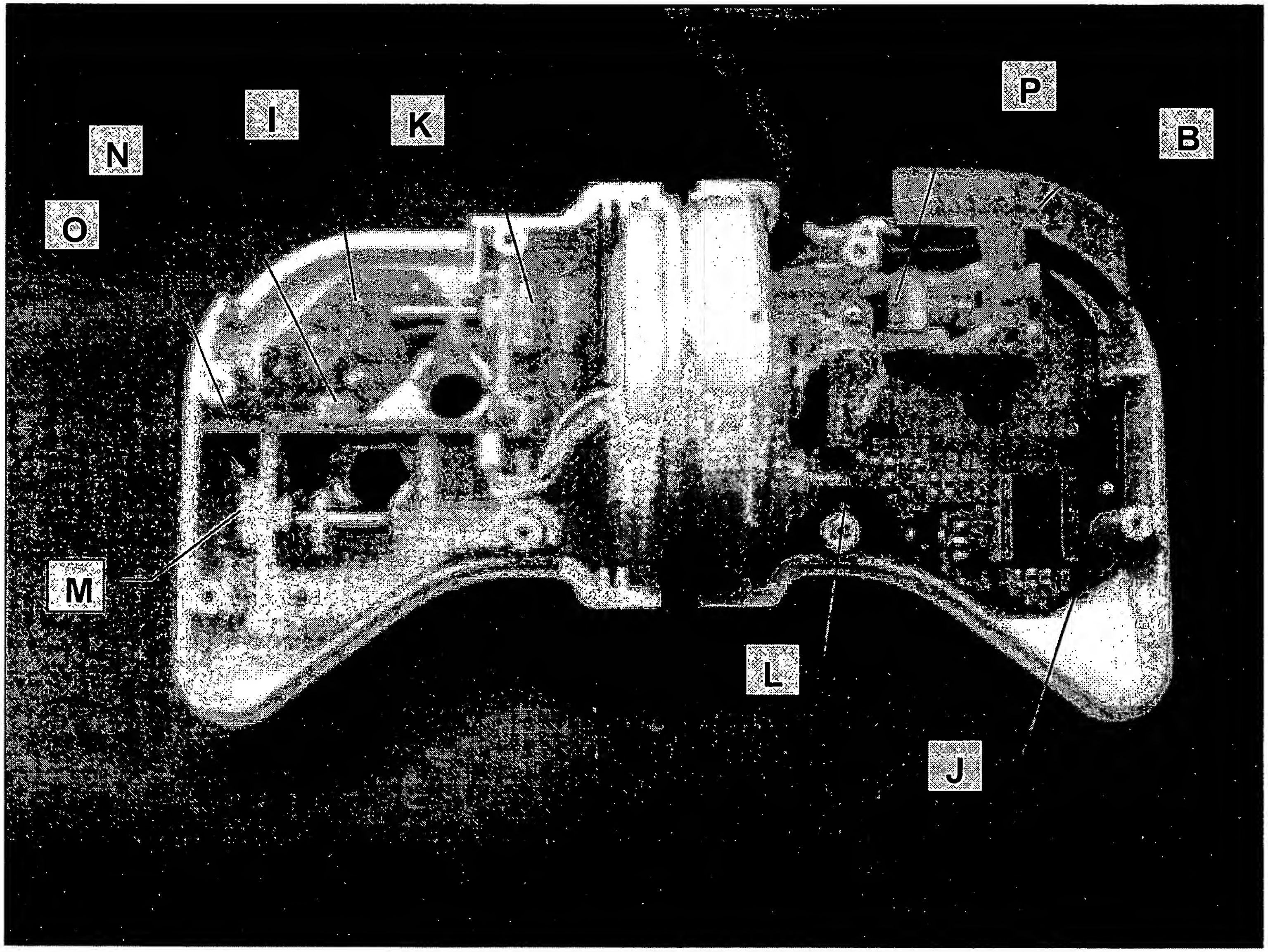

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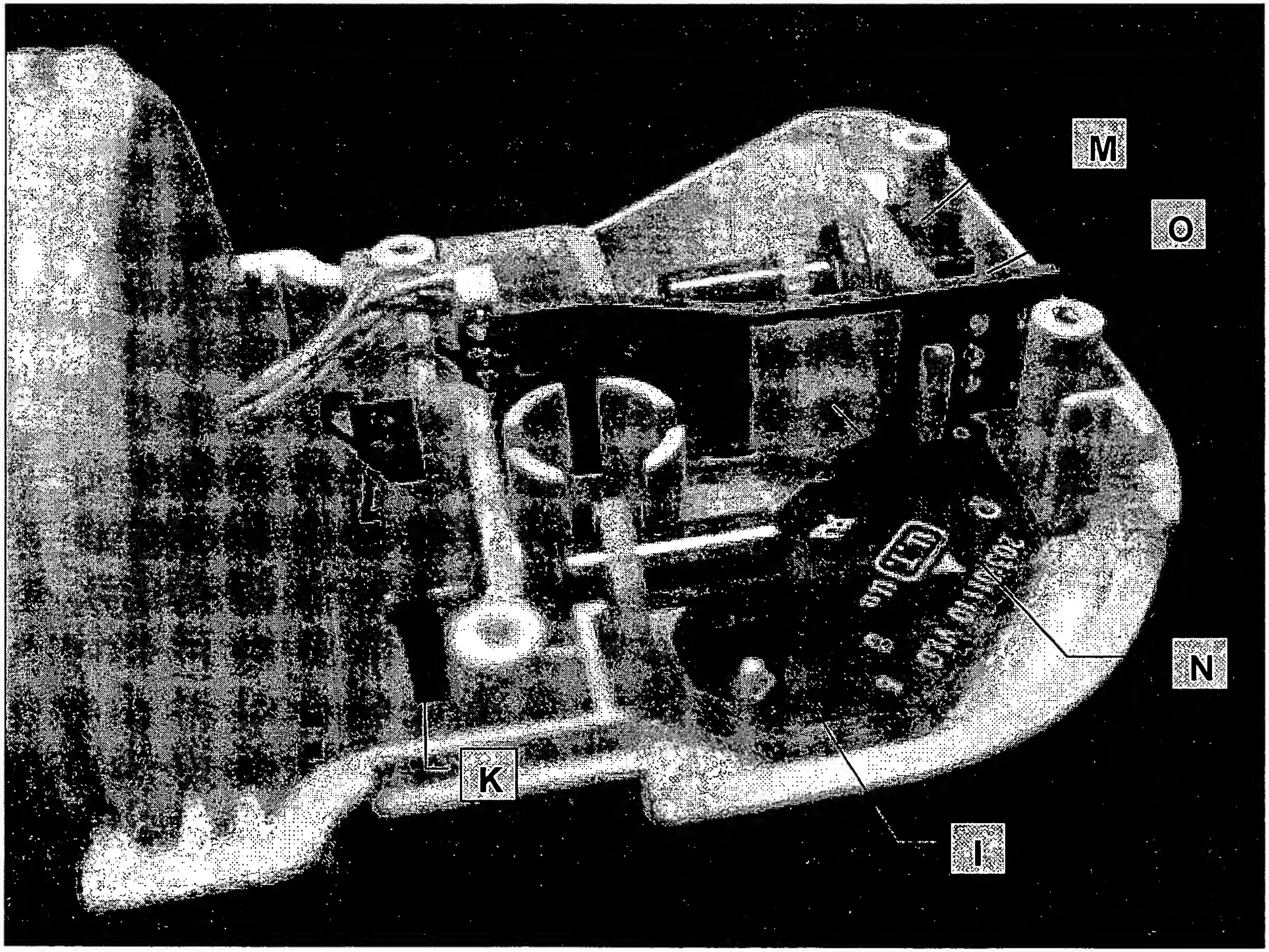

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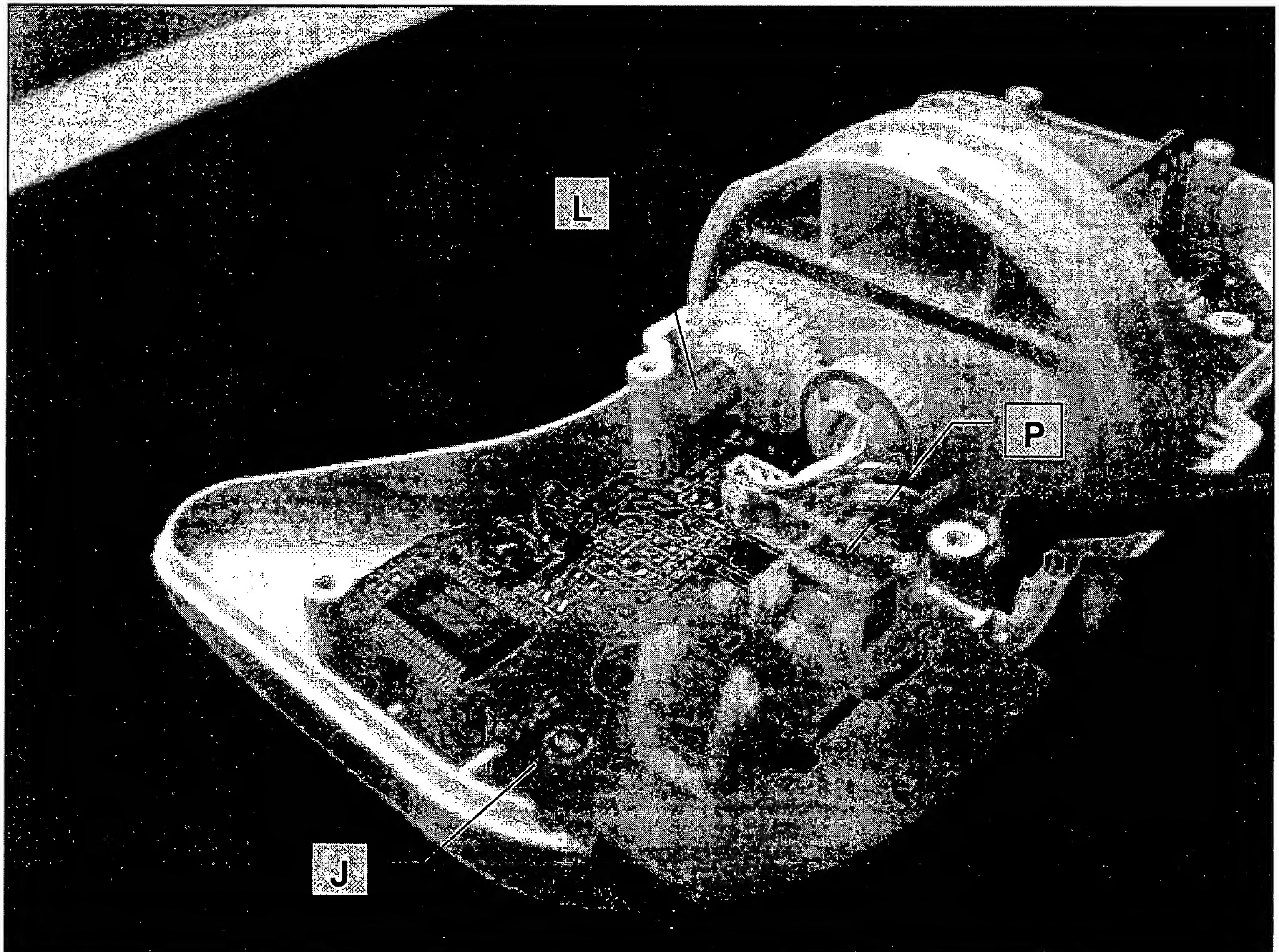

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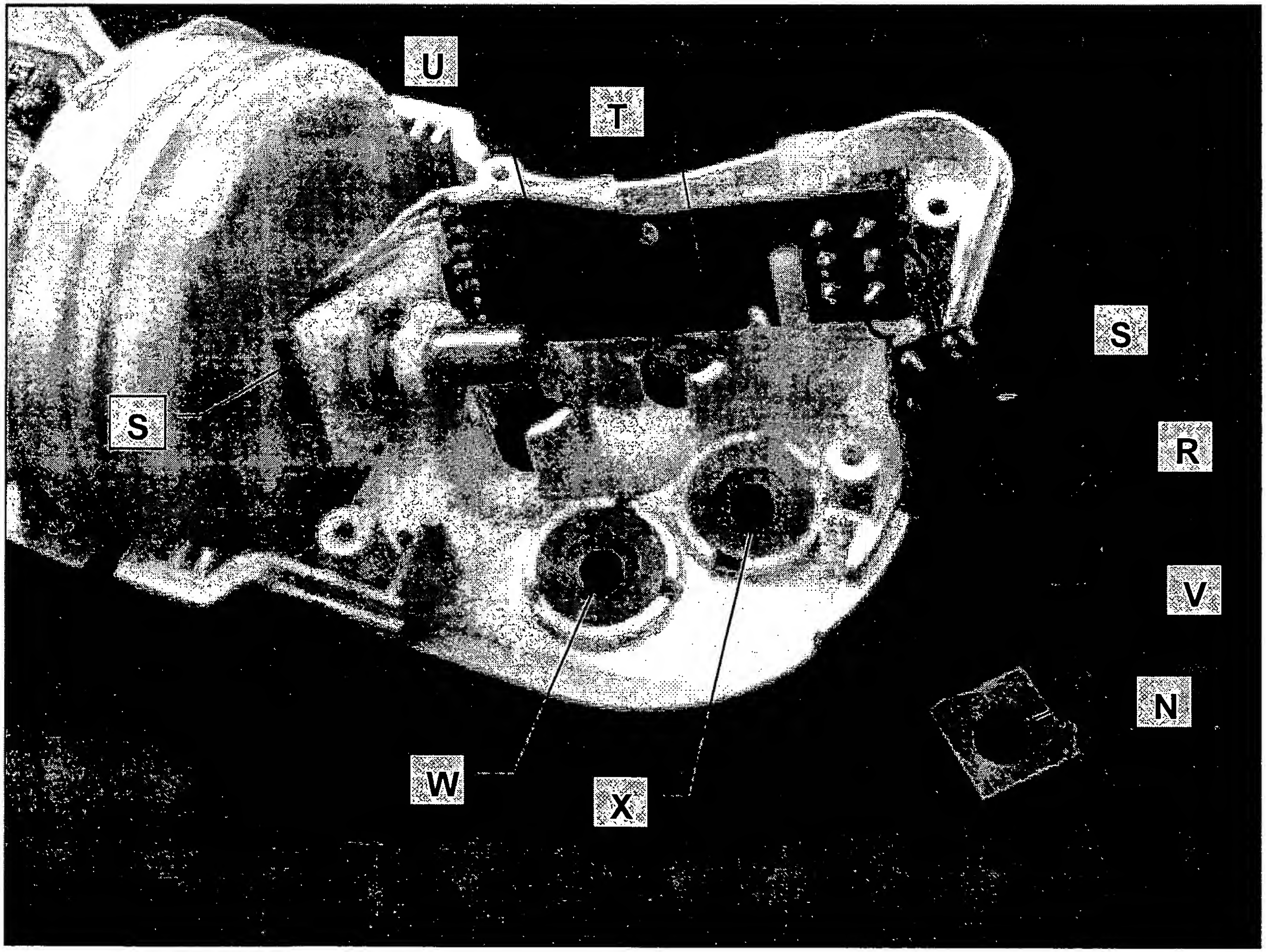

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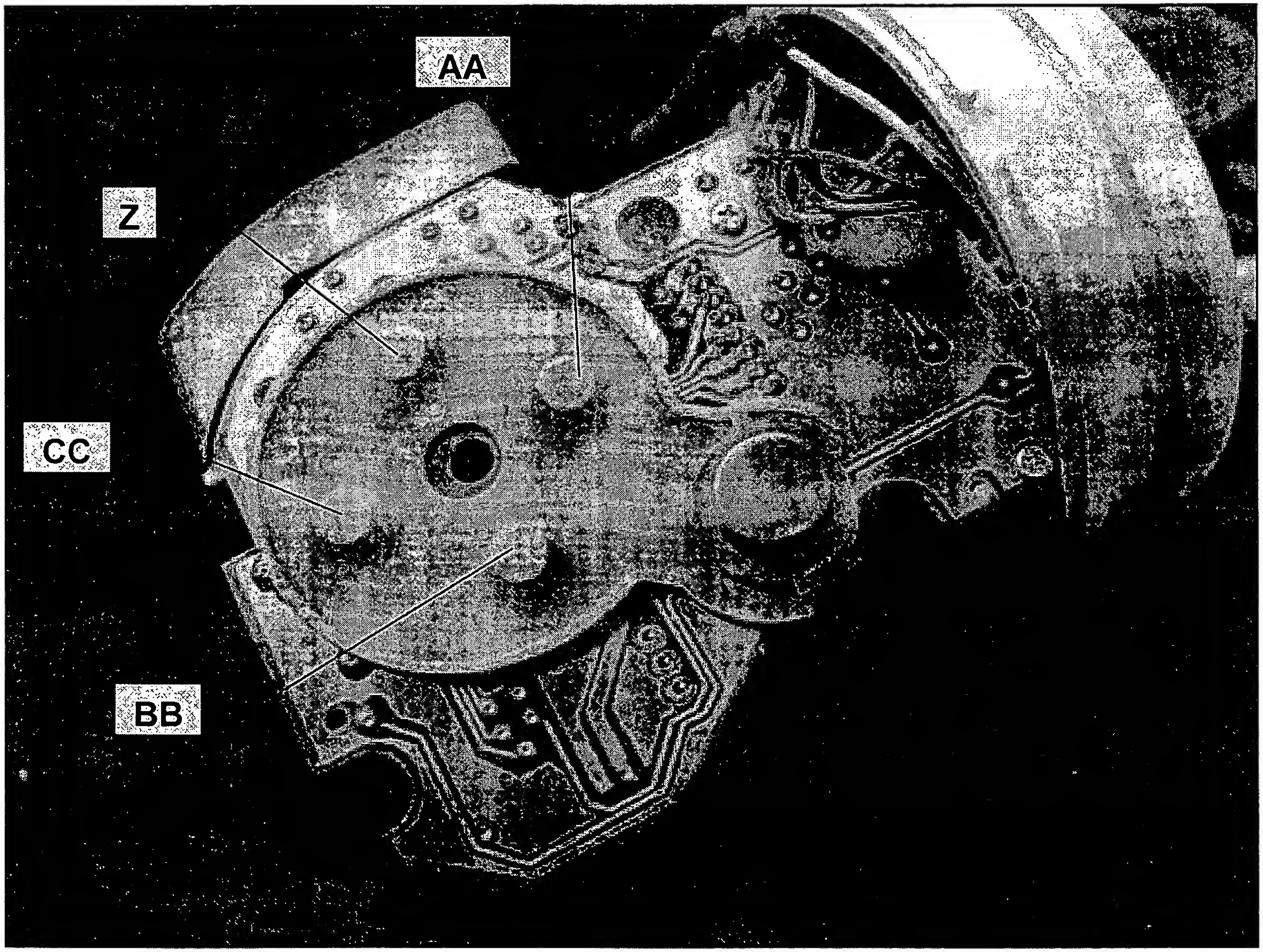

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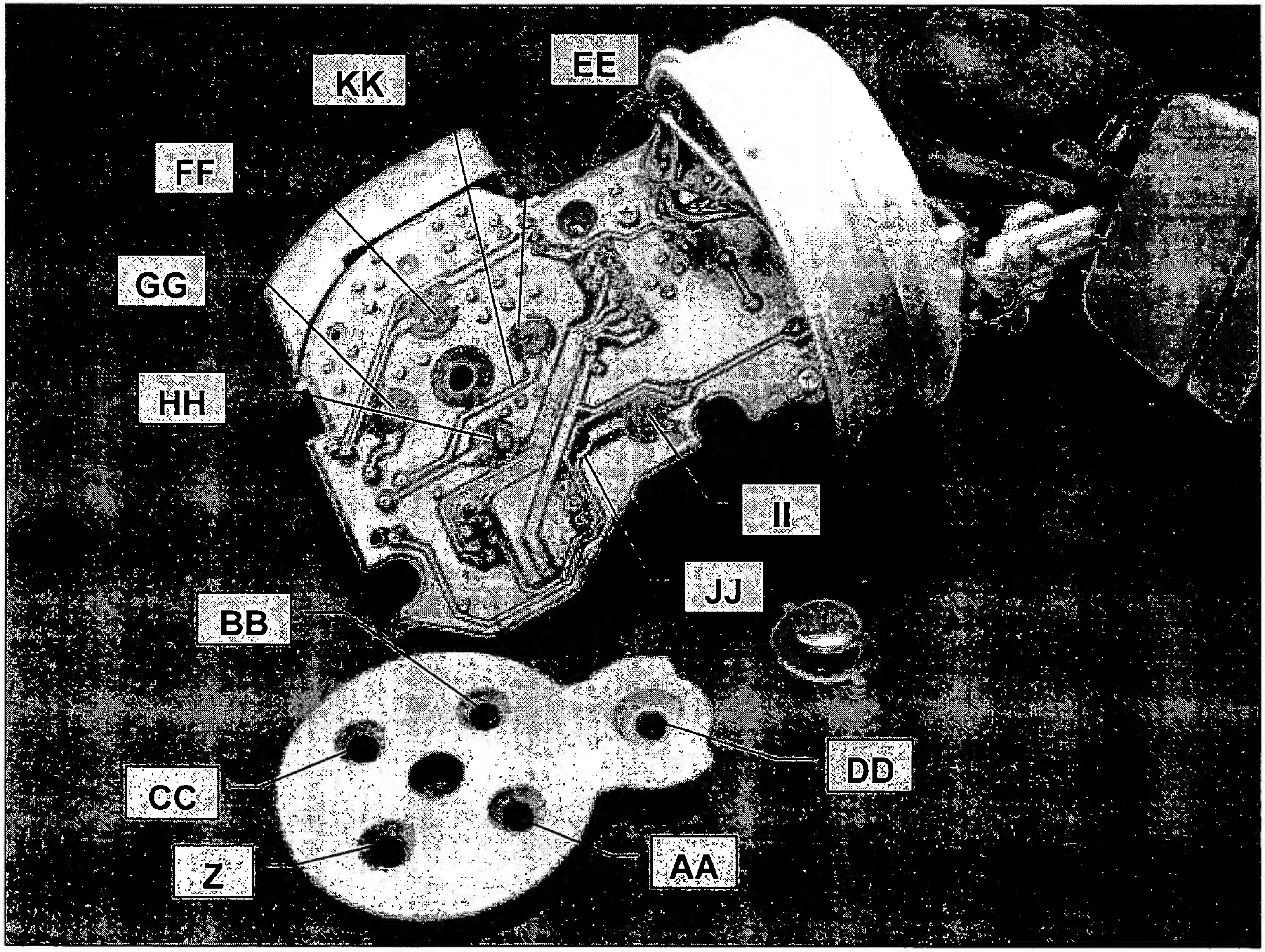
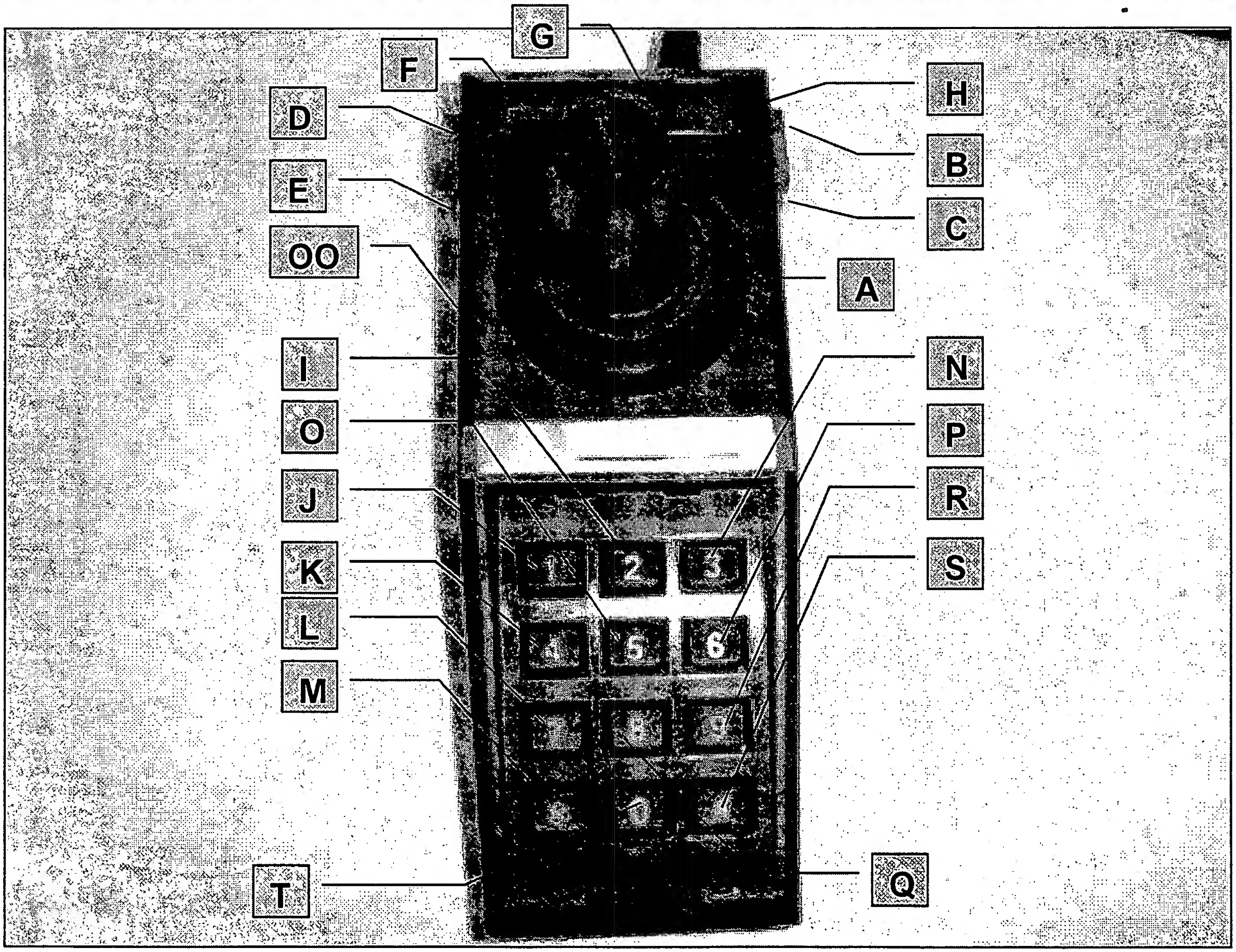


Atari 5200 Controller



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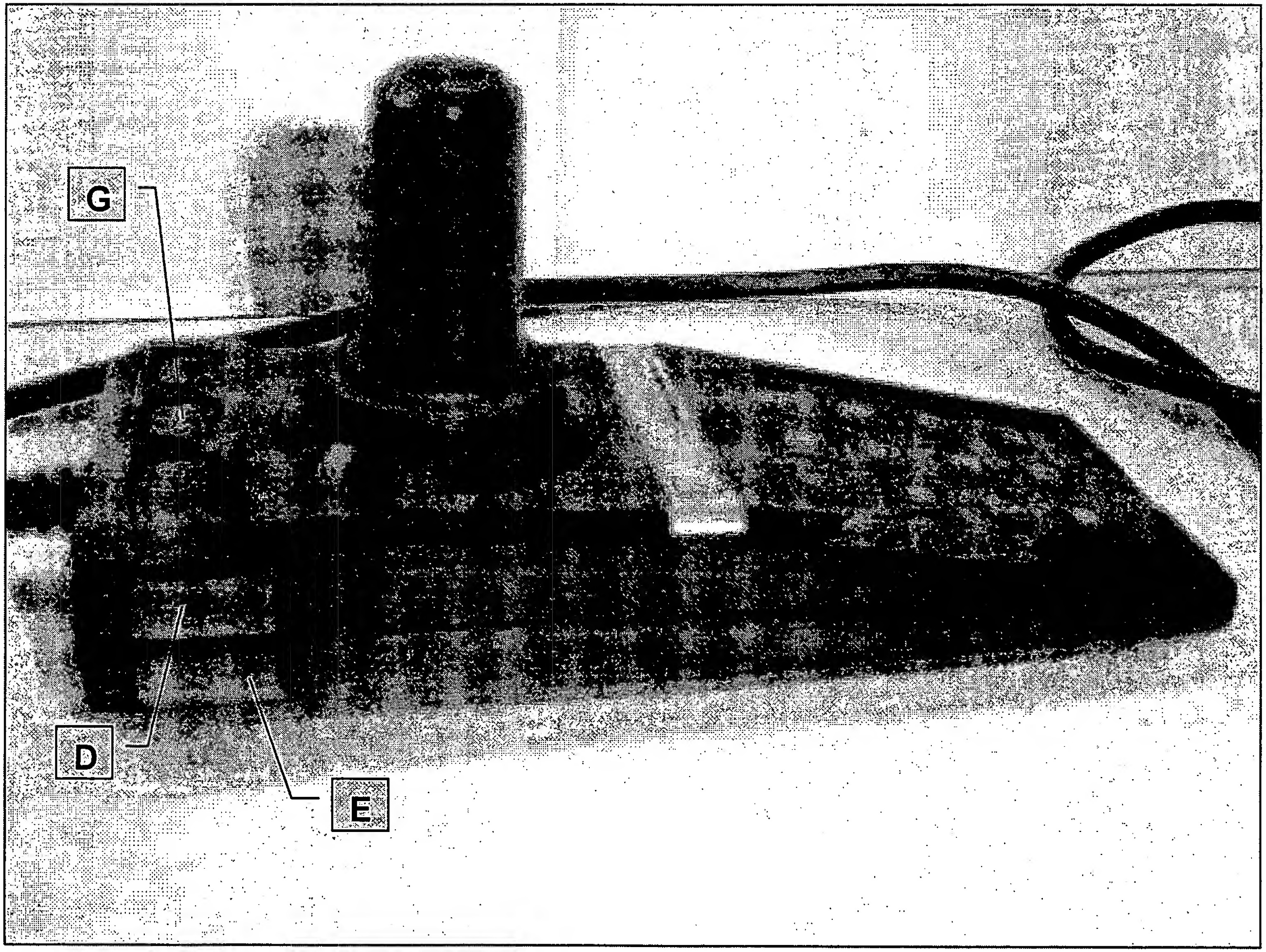

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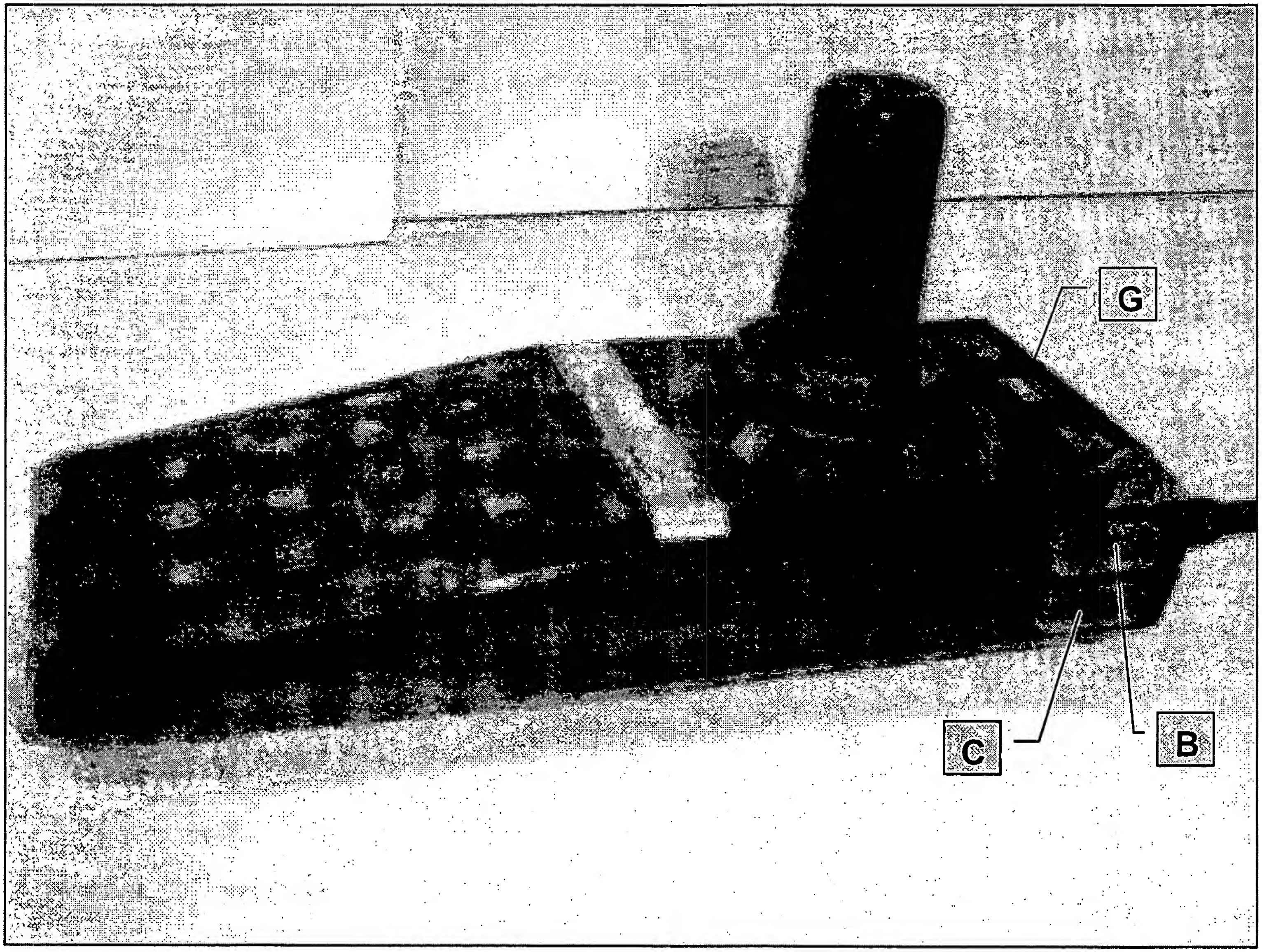

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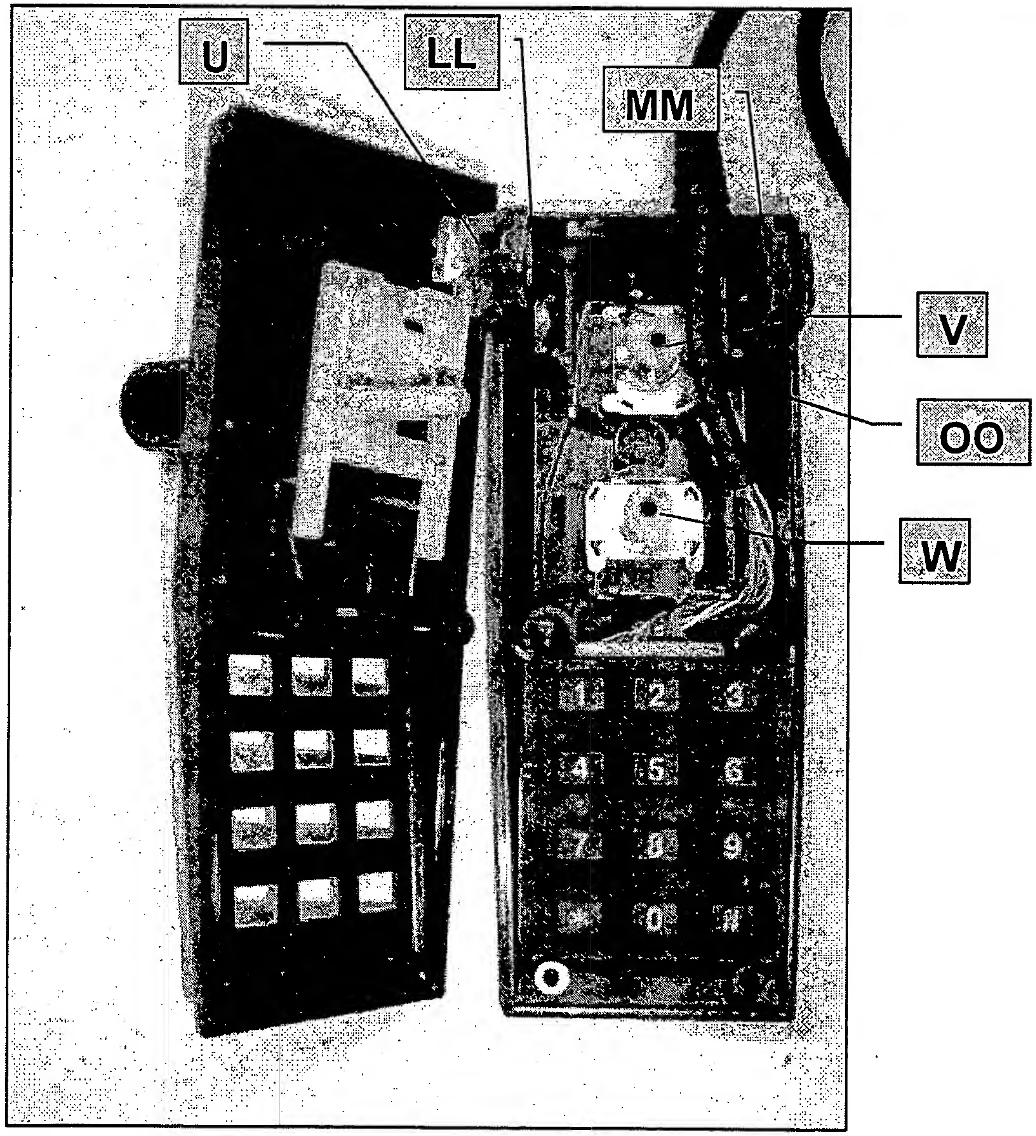

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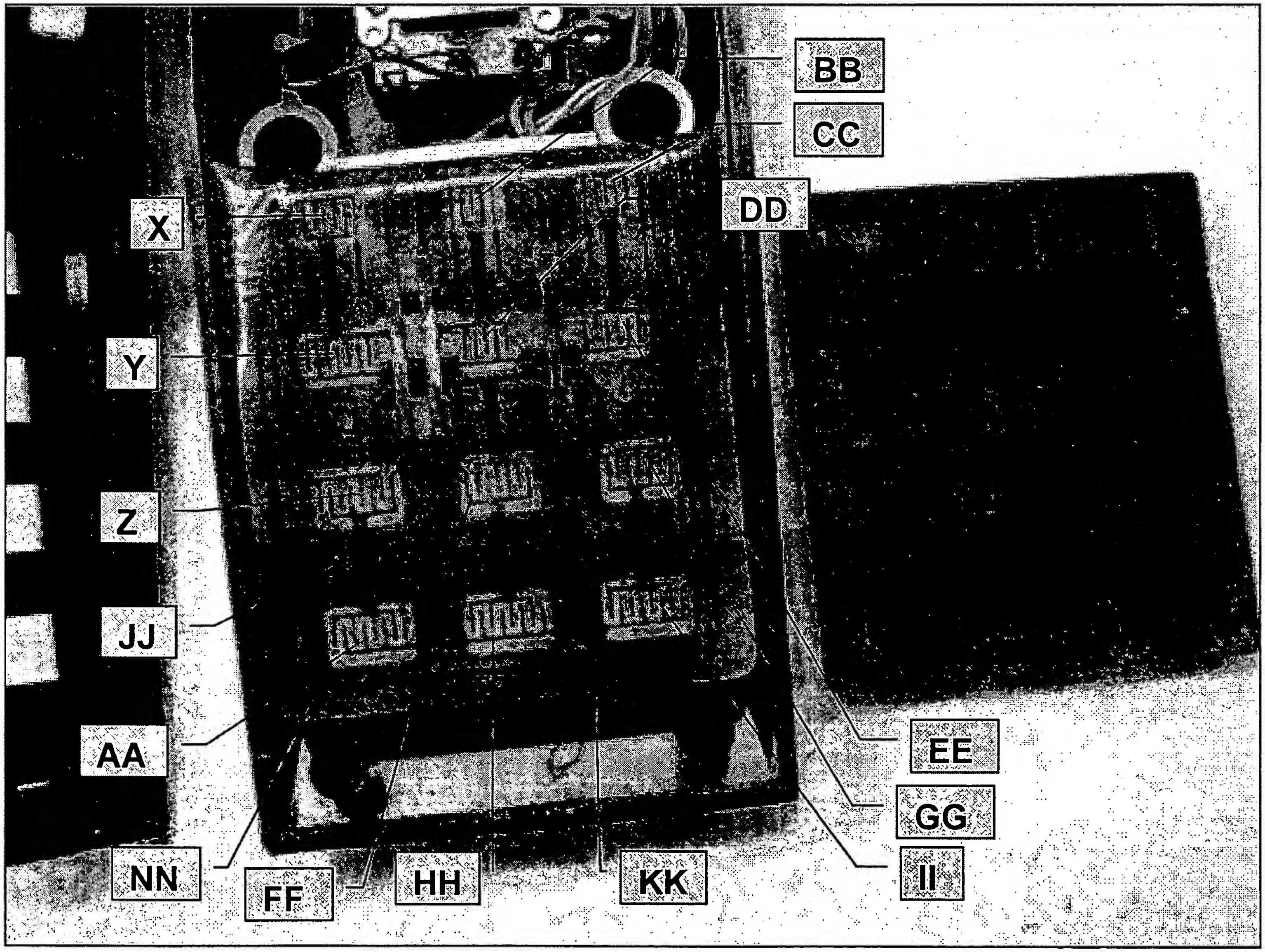

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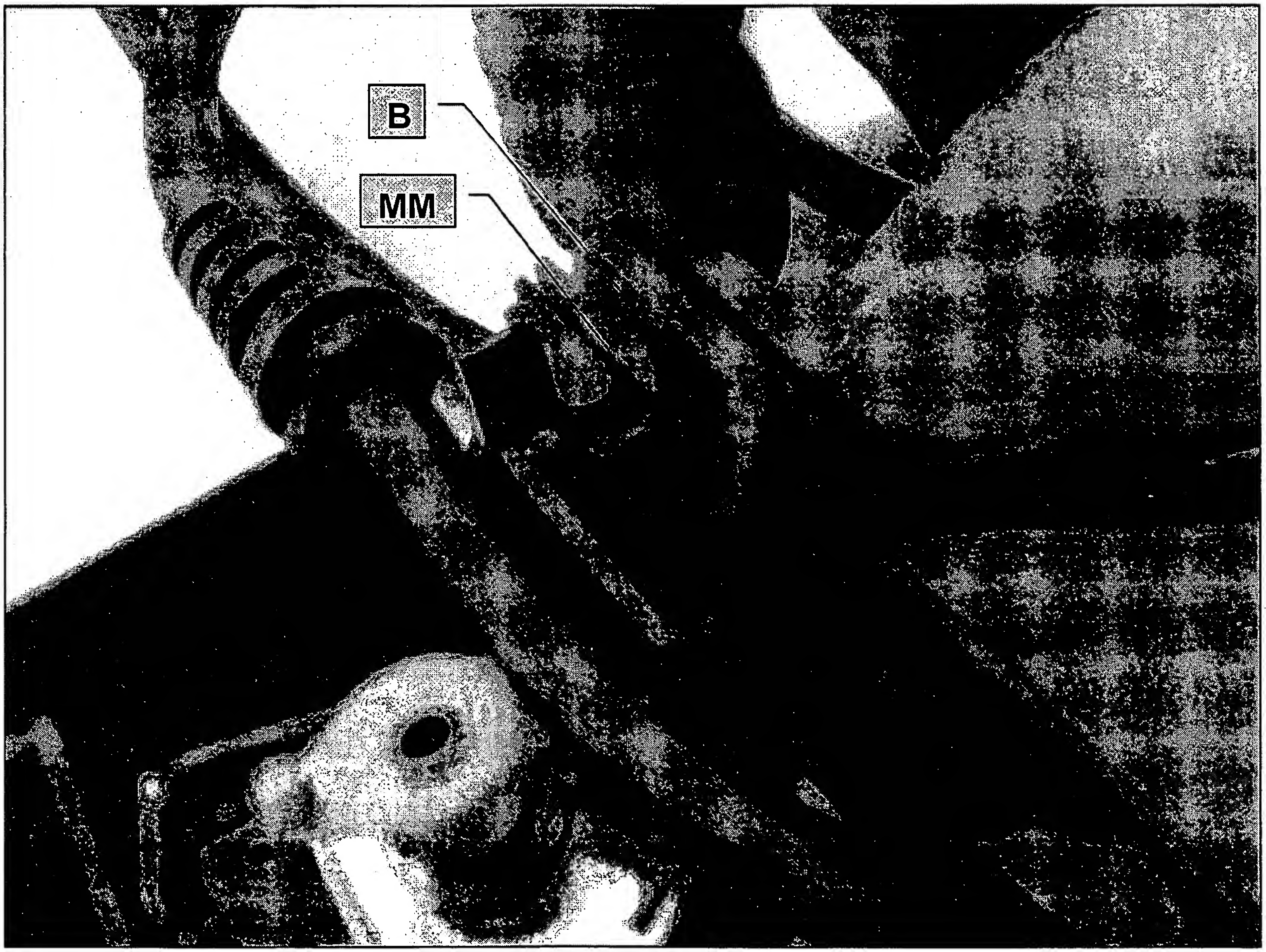

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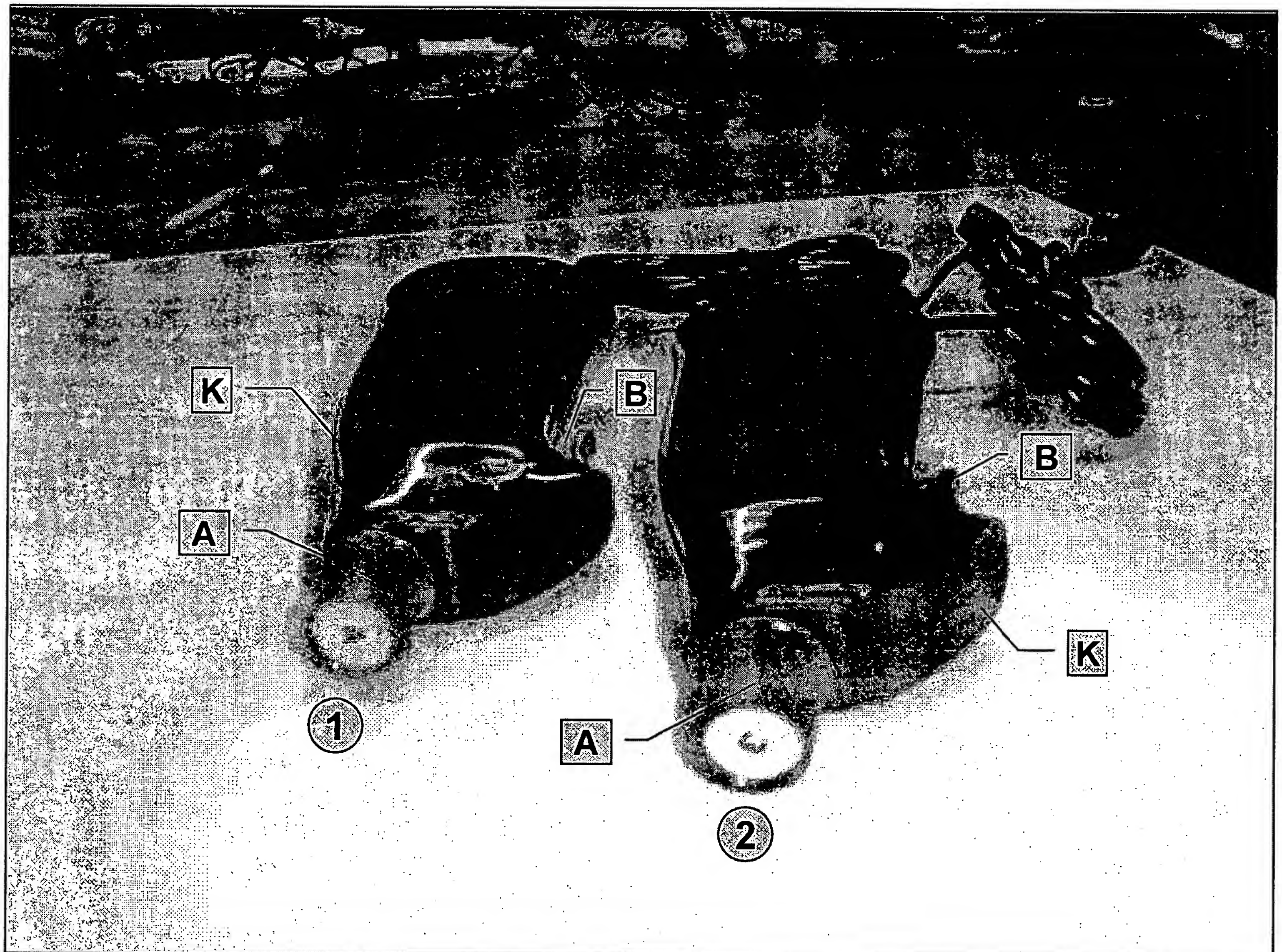
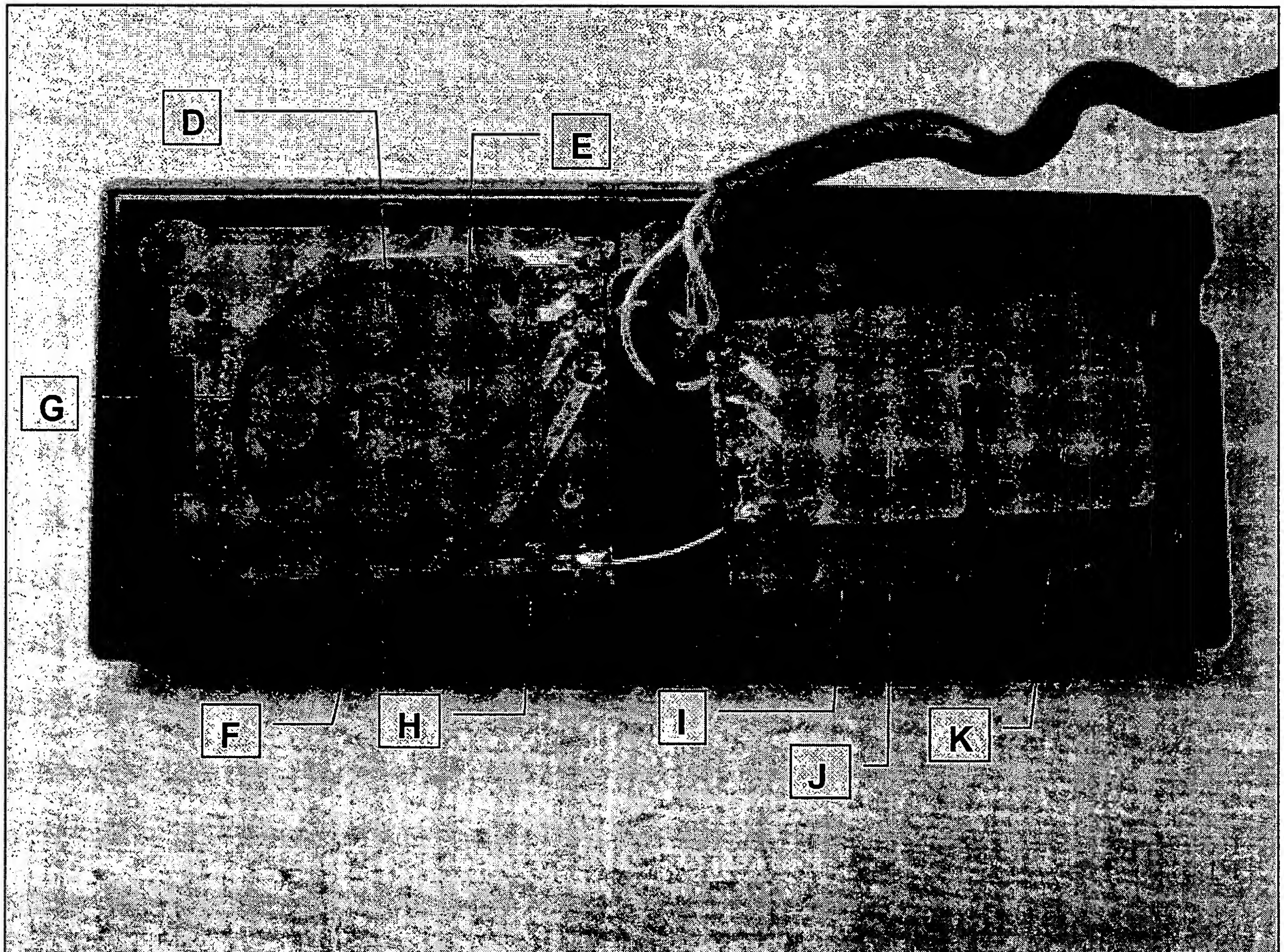


Sega 3020 Controller

Sega 3020 Controller



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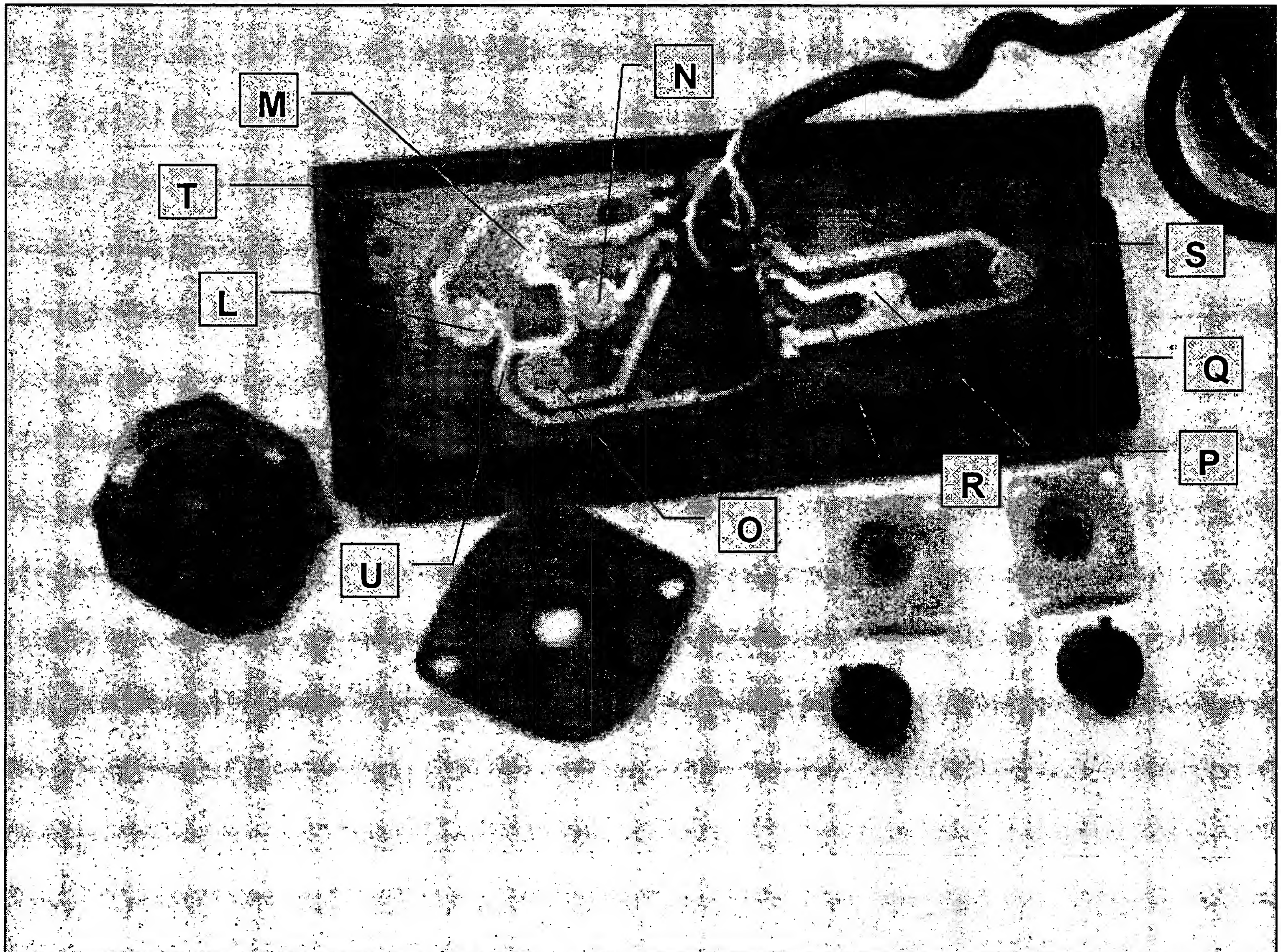
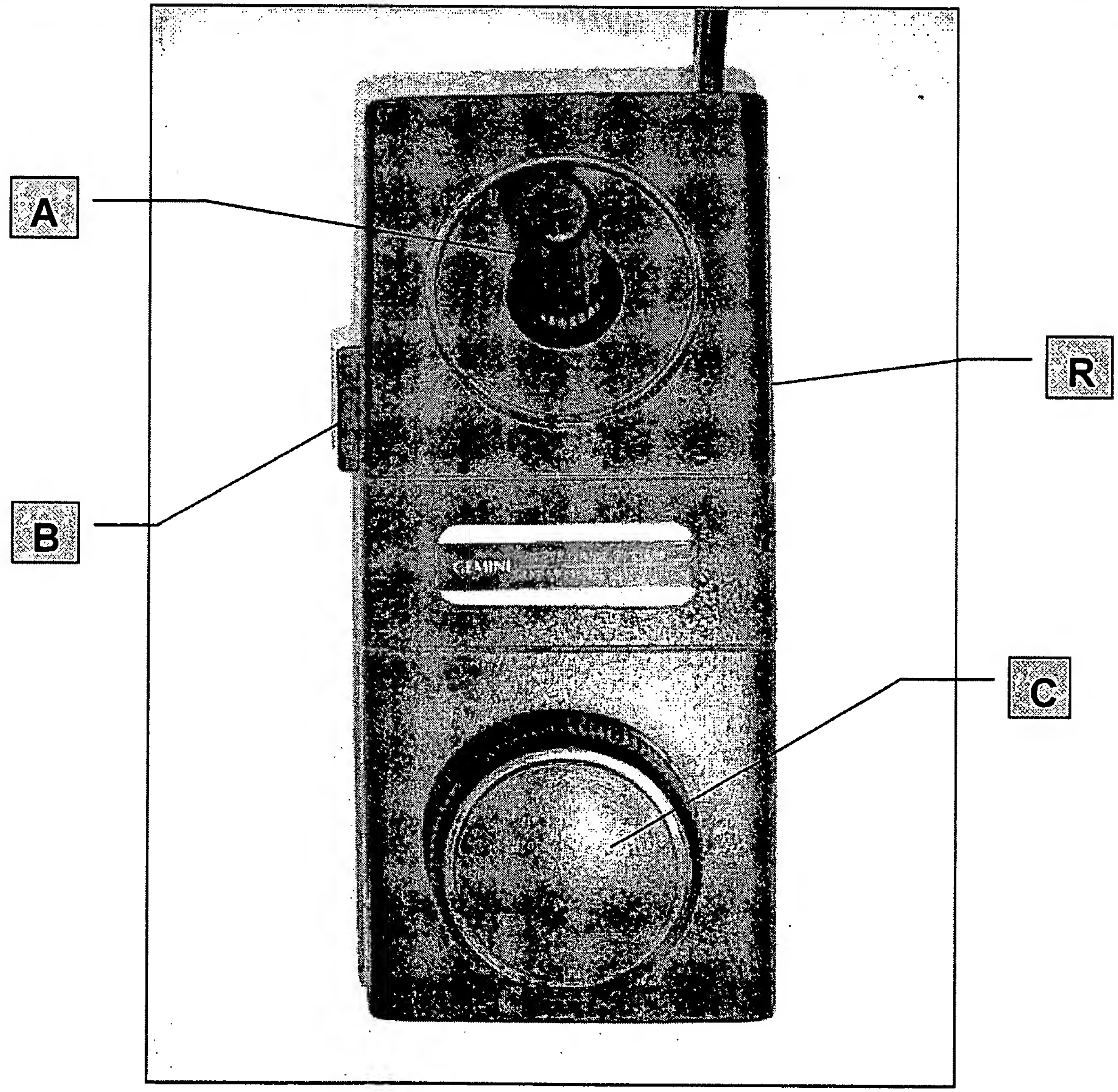


Coleco Gemini Controller



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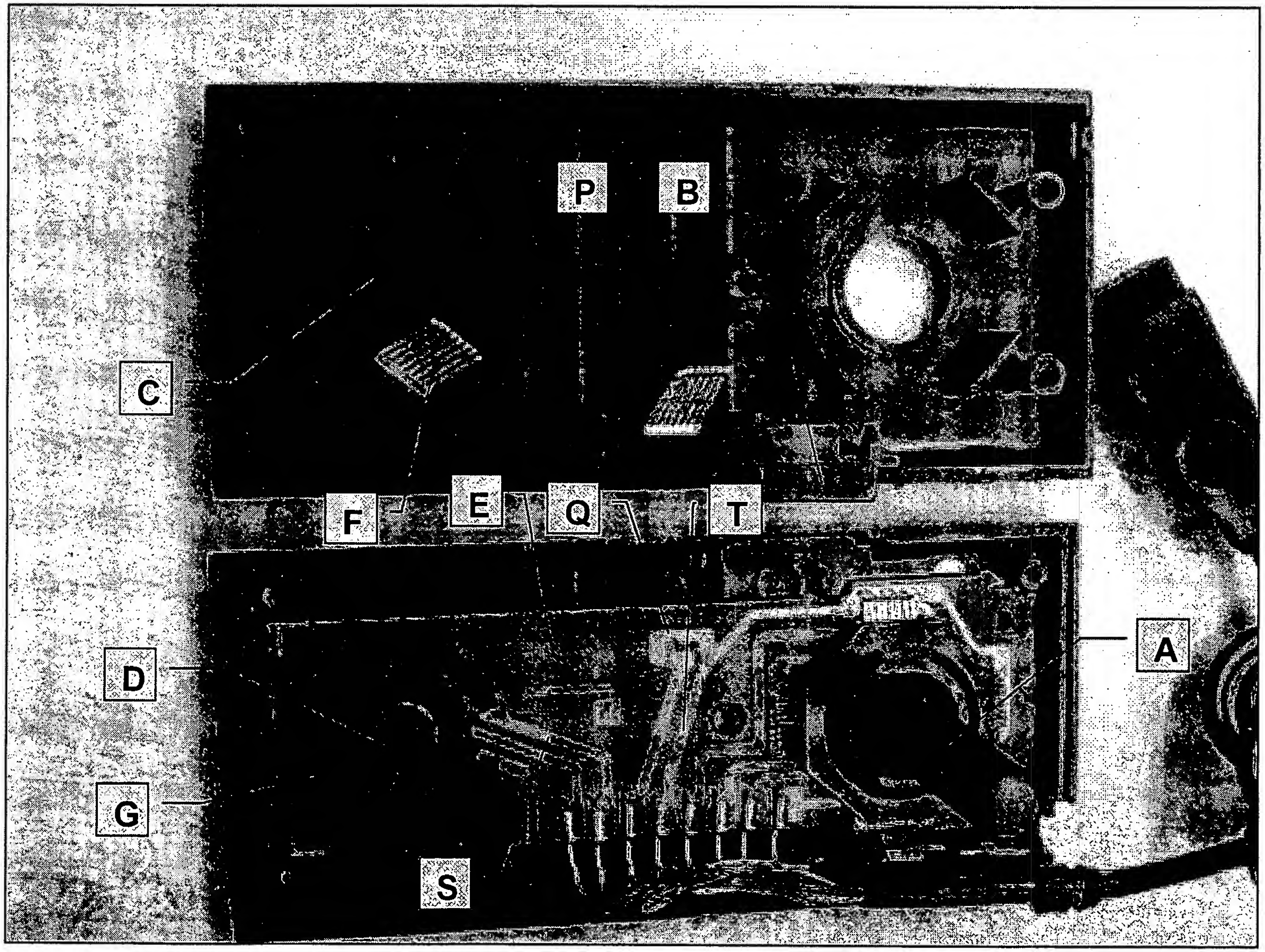

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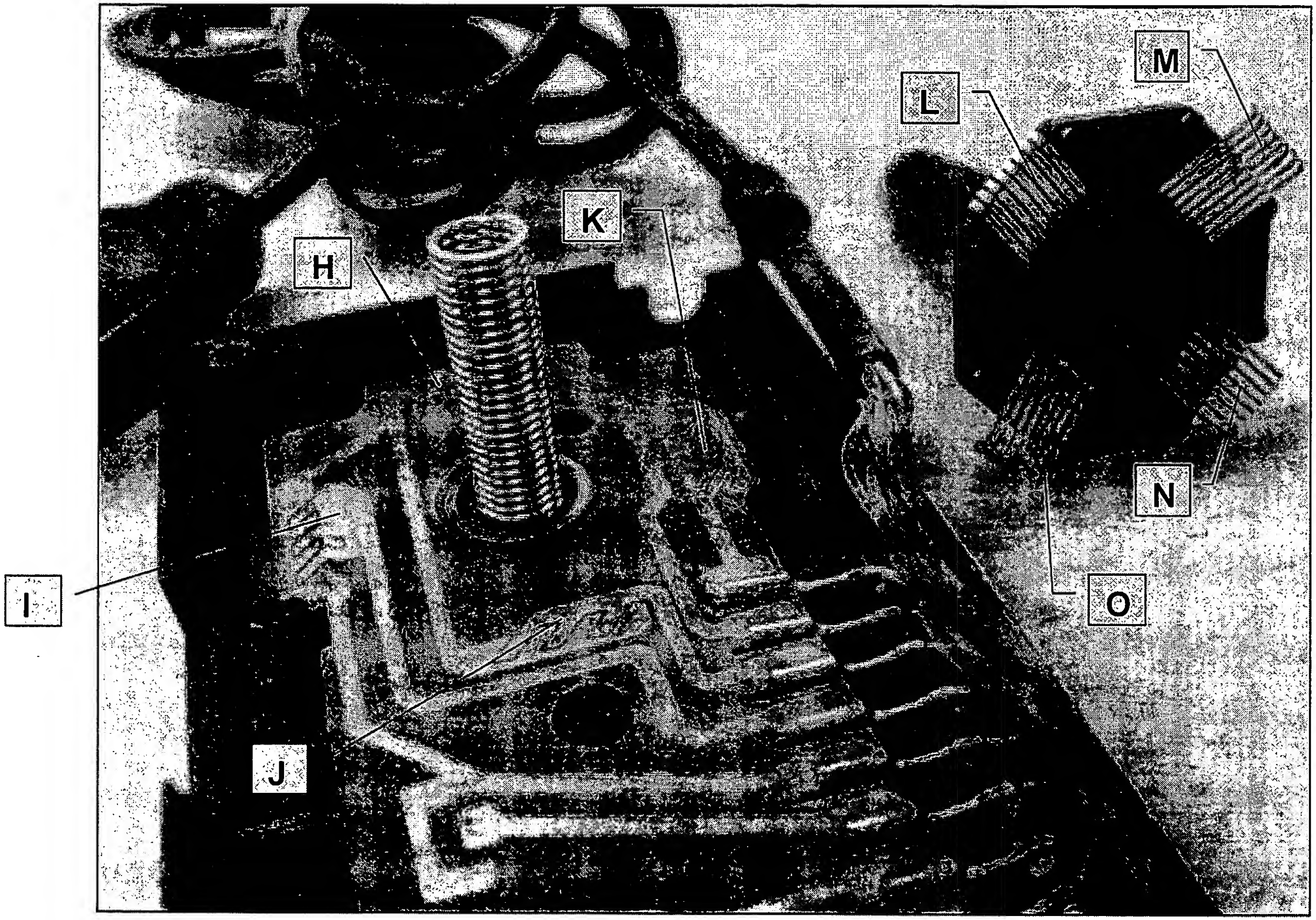

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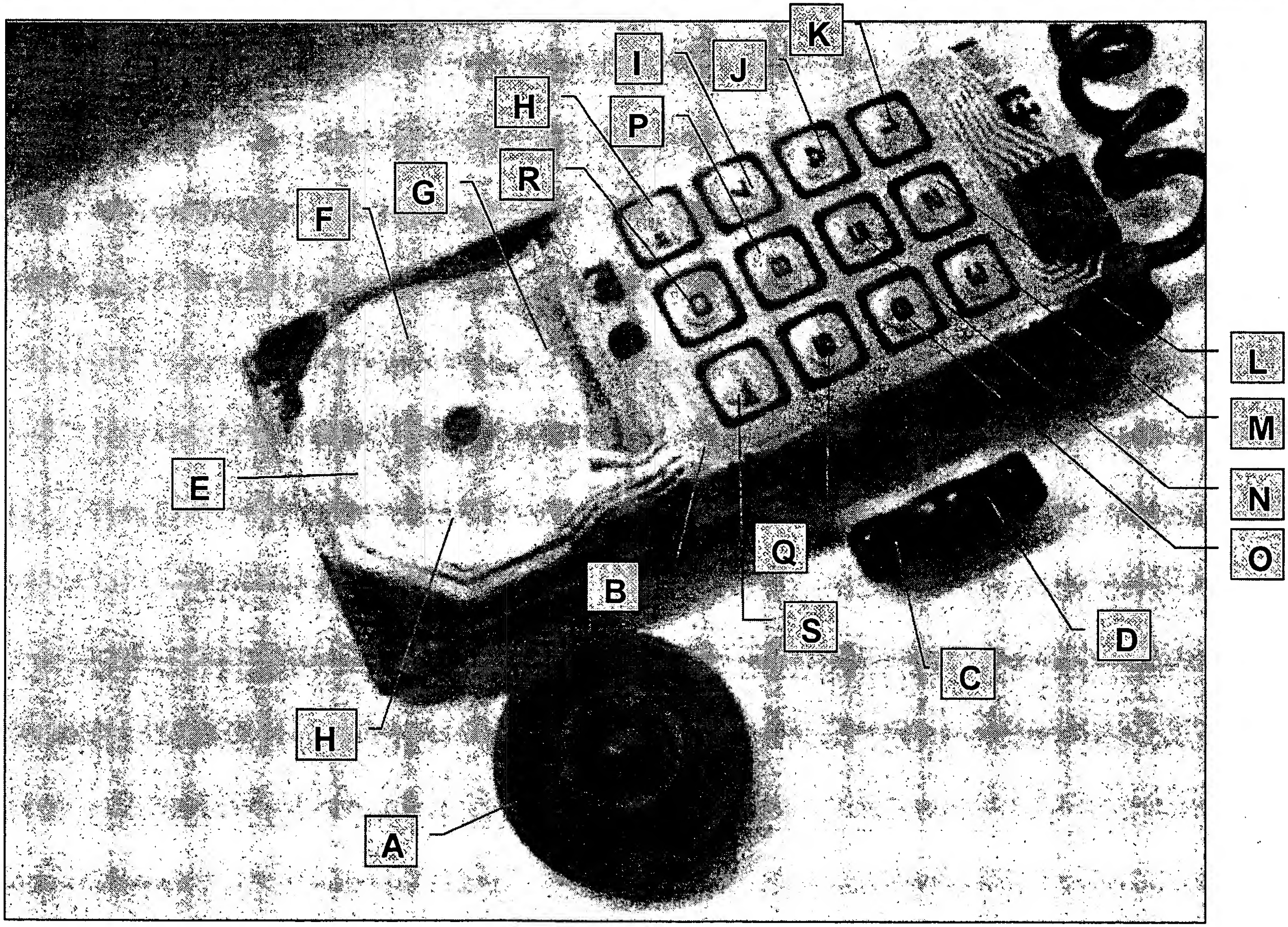

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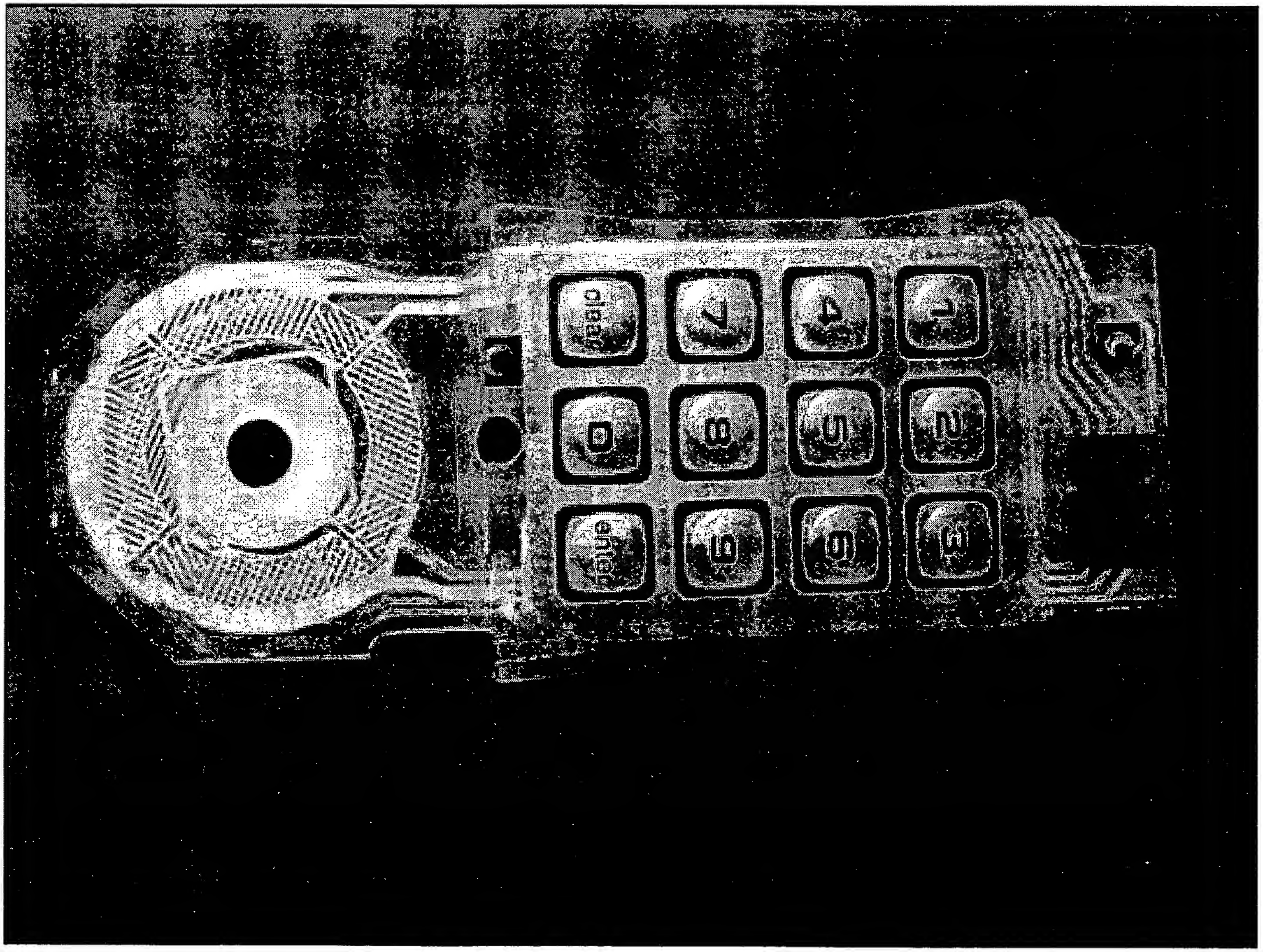

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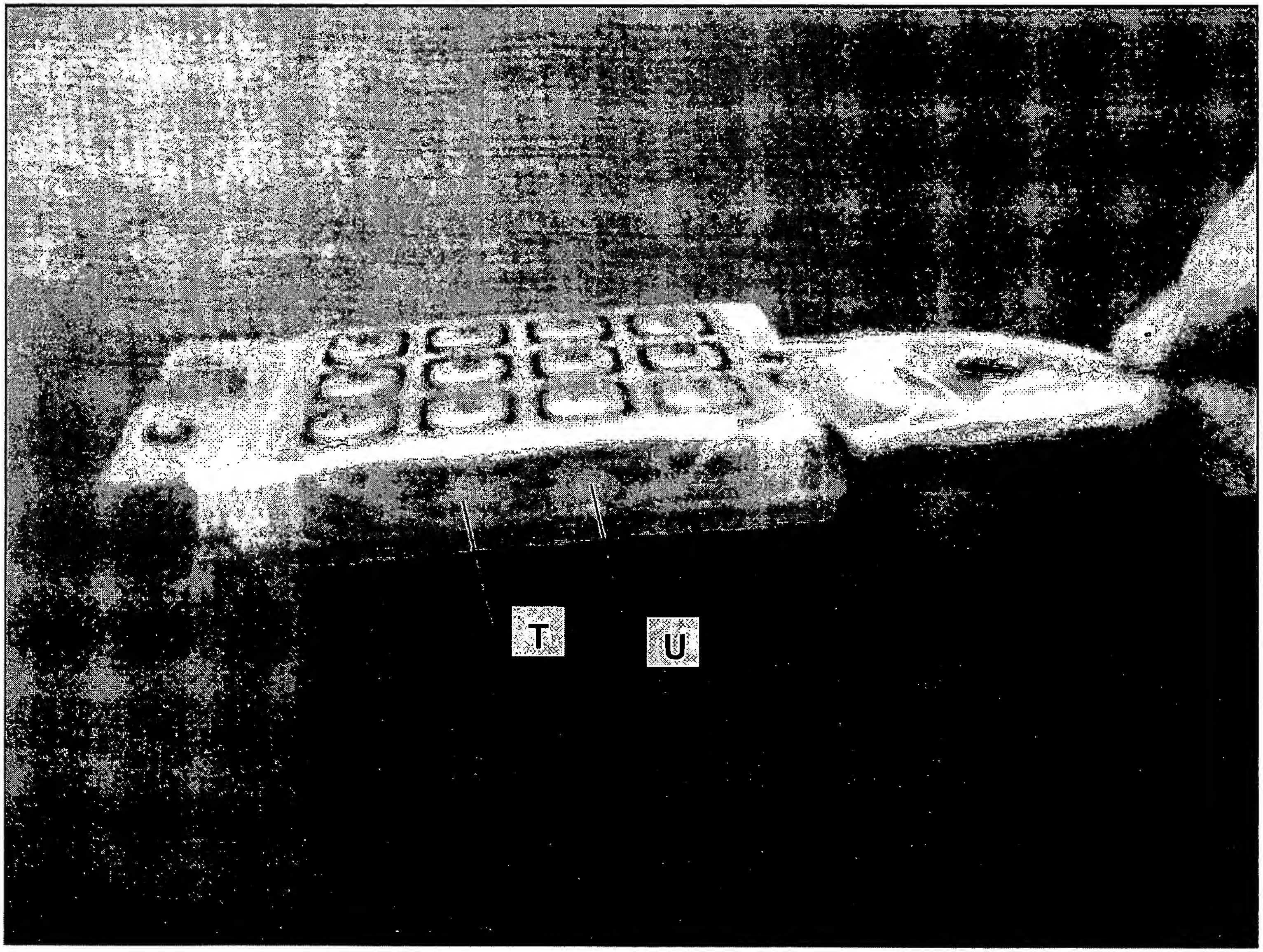

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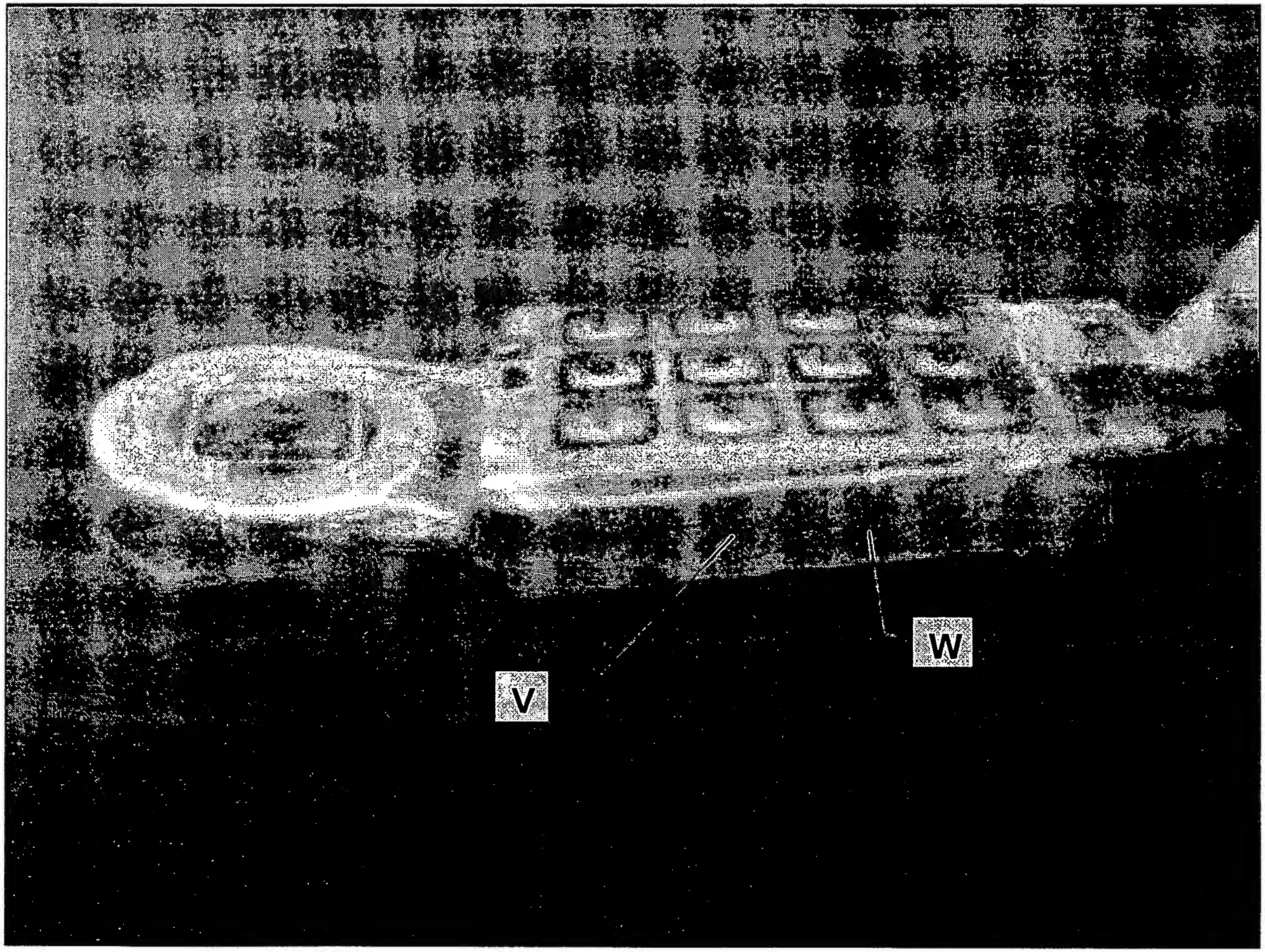

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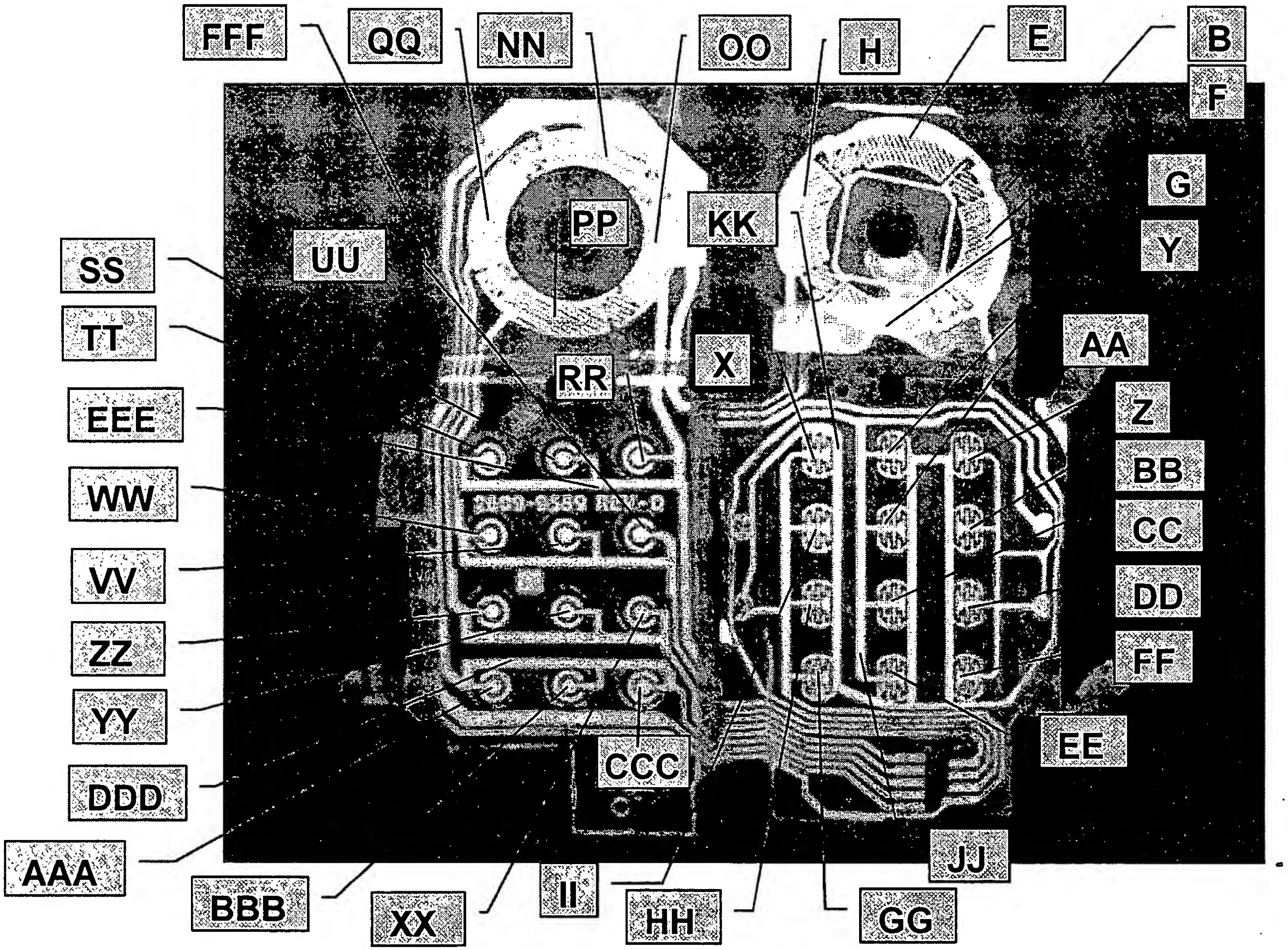

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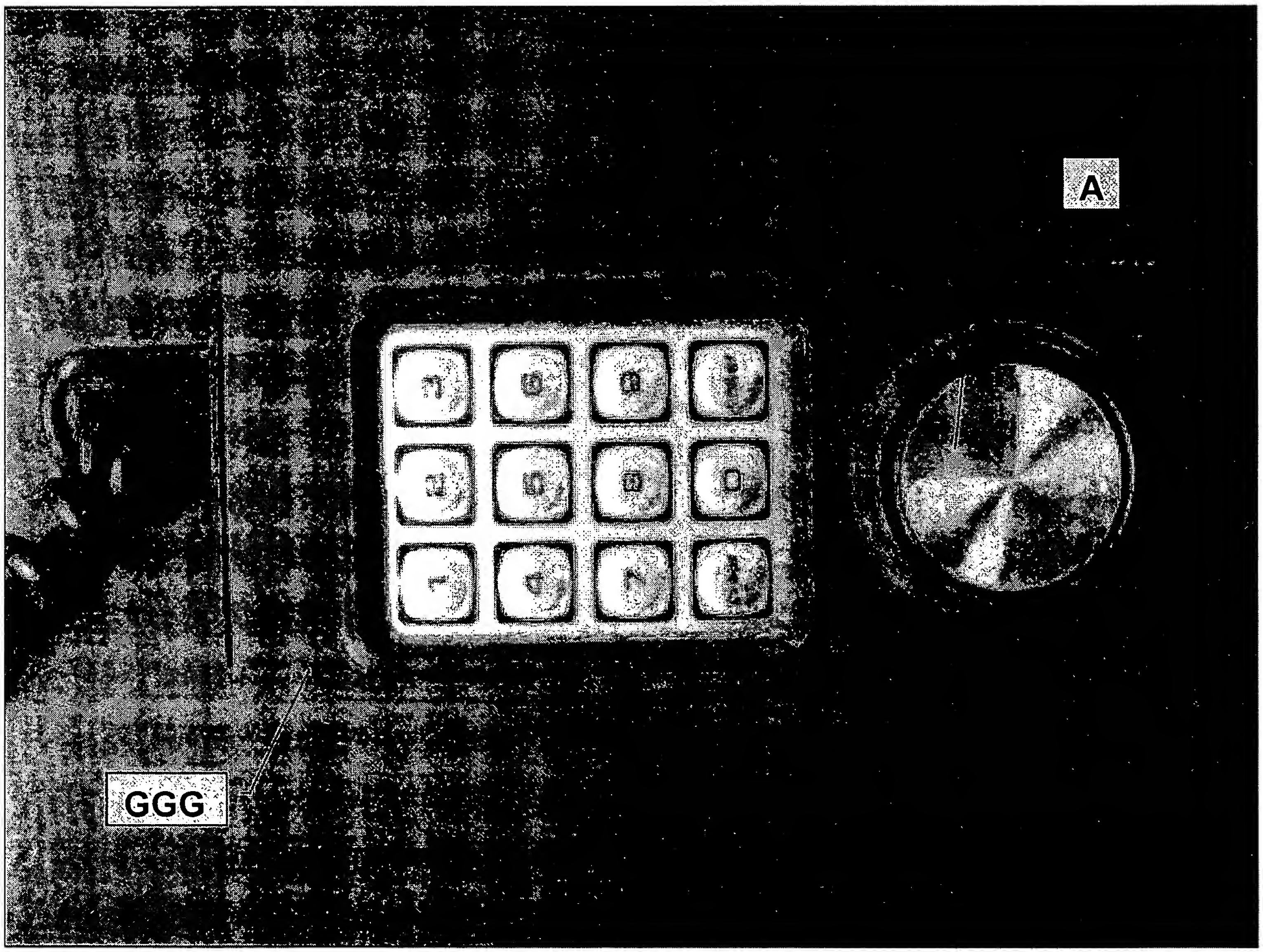

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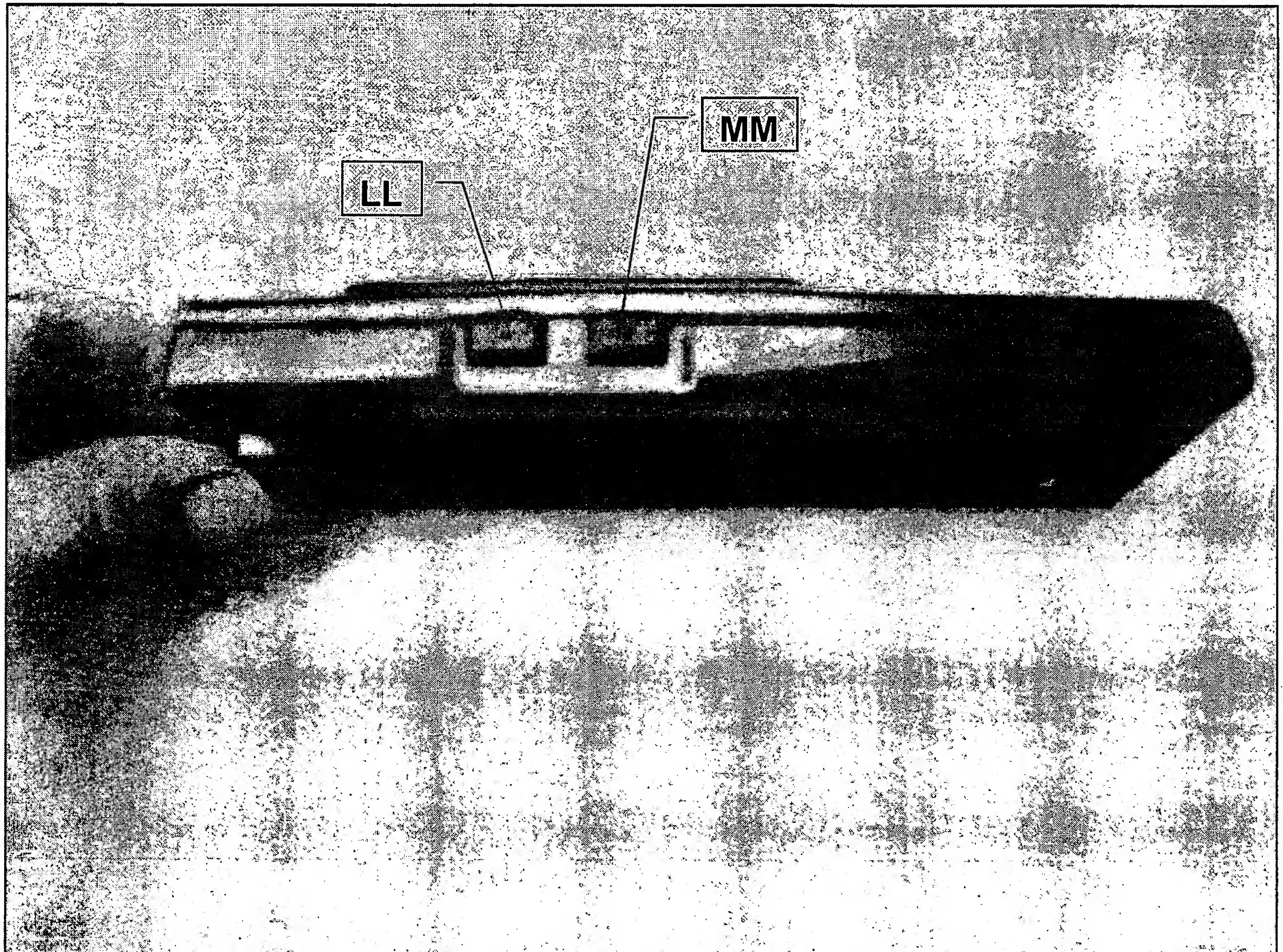

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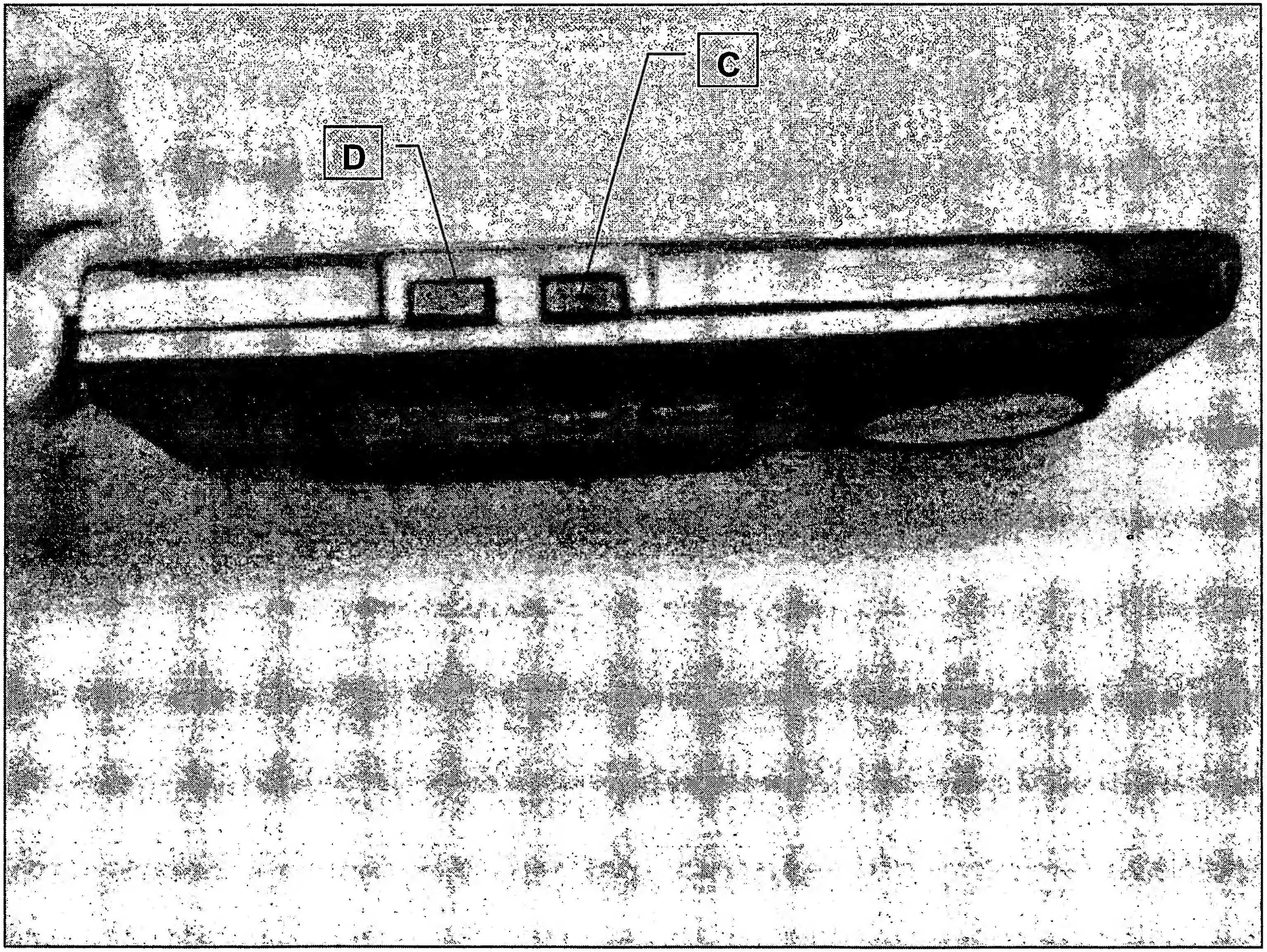
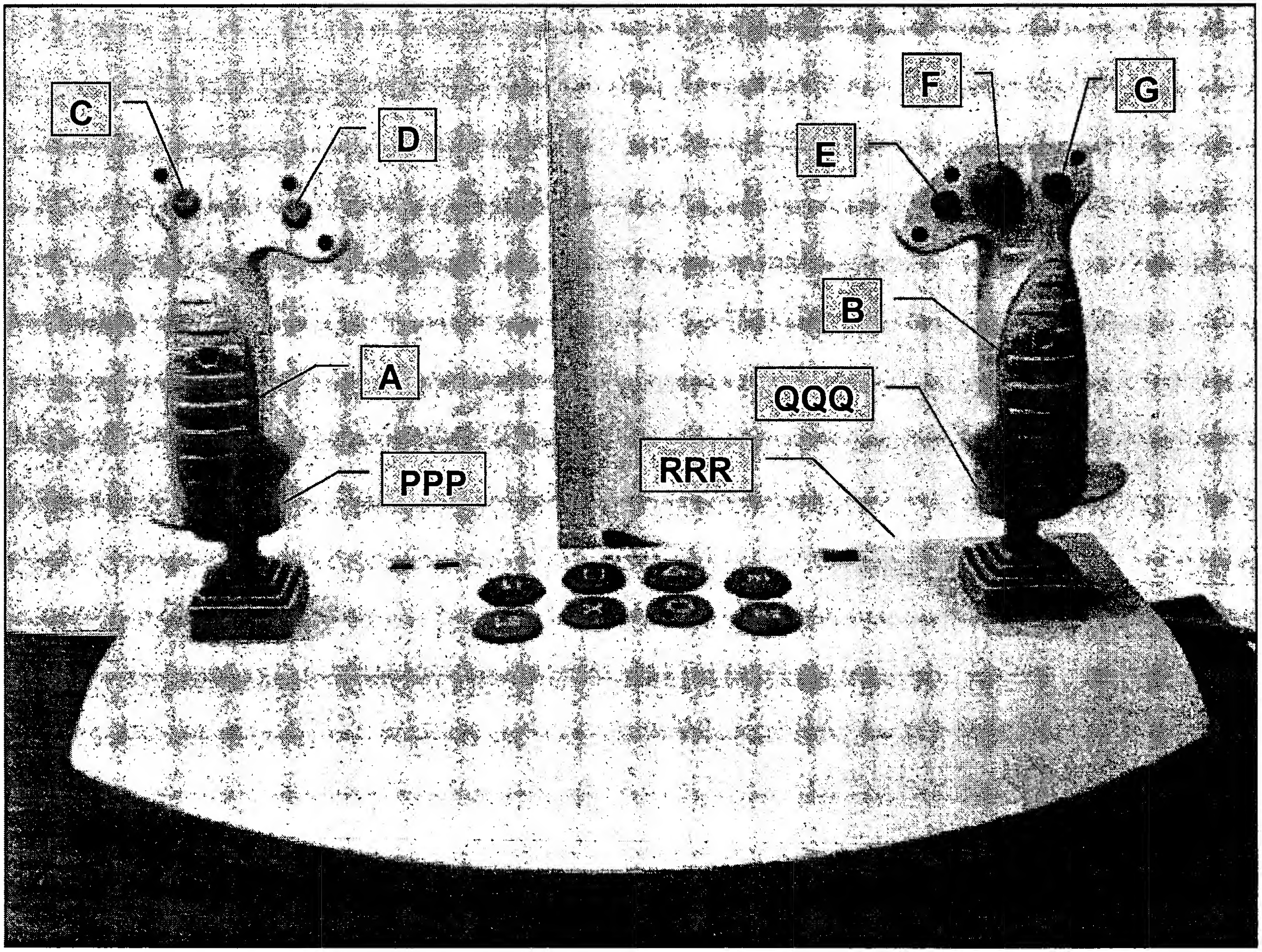


Intellivision Controllers

Sony Flightsick Controller



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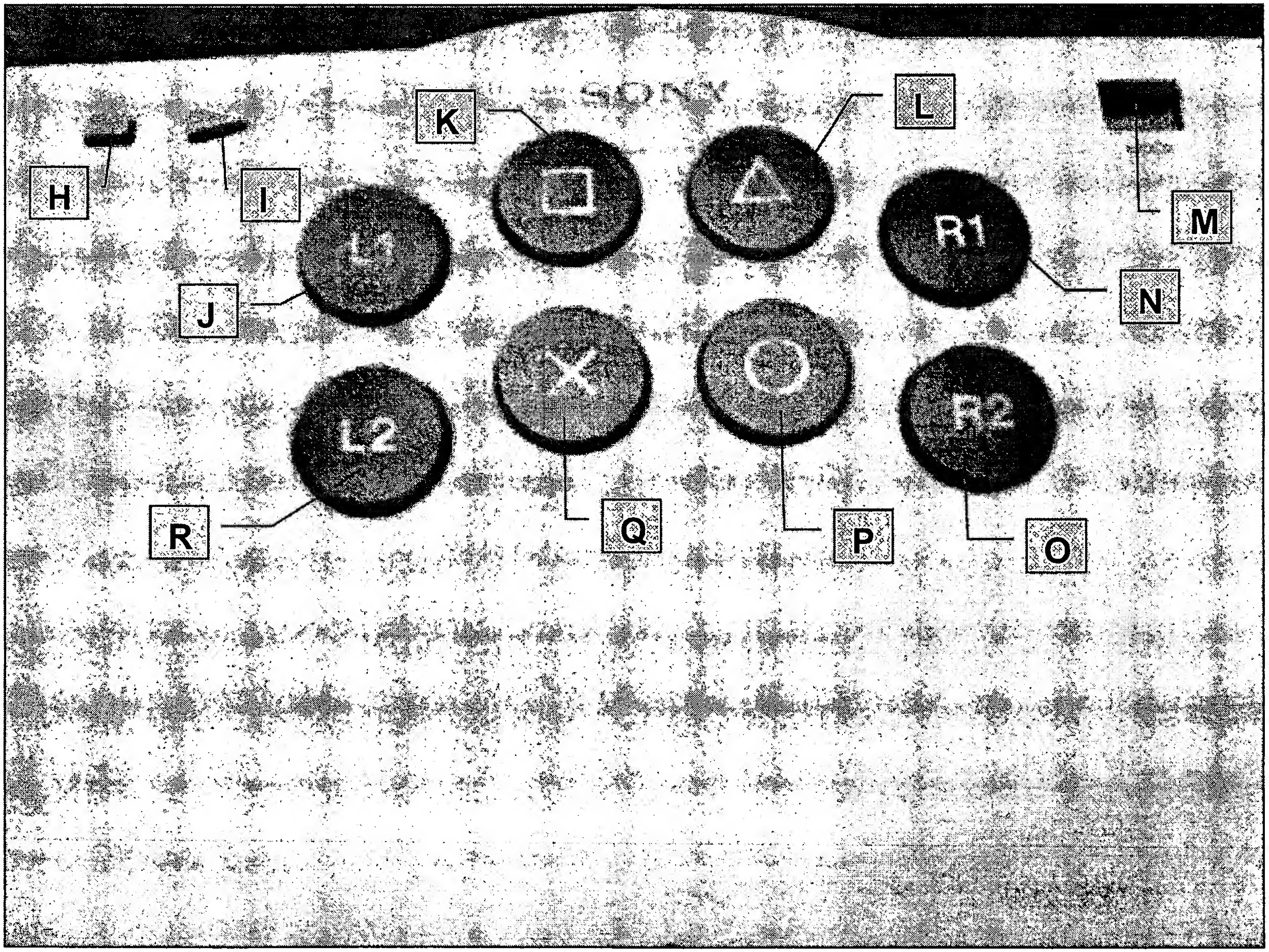

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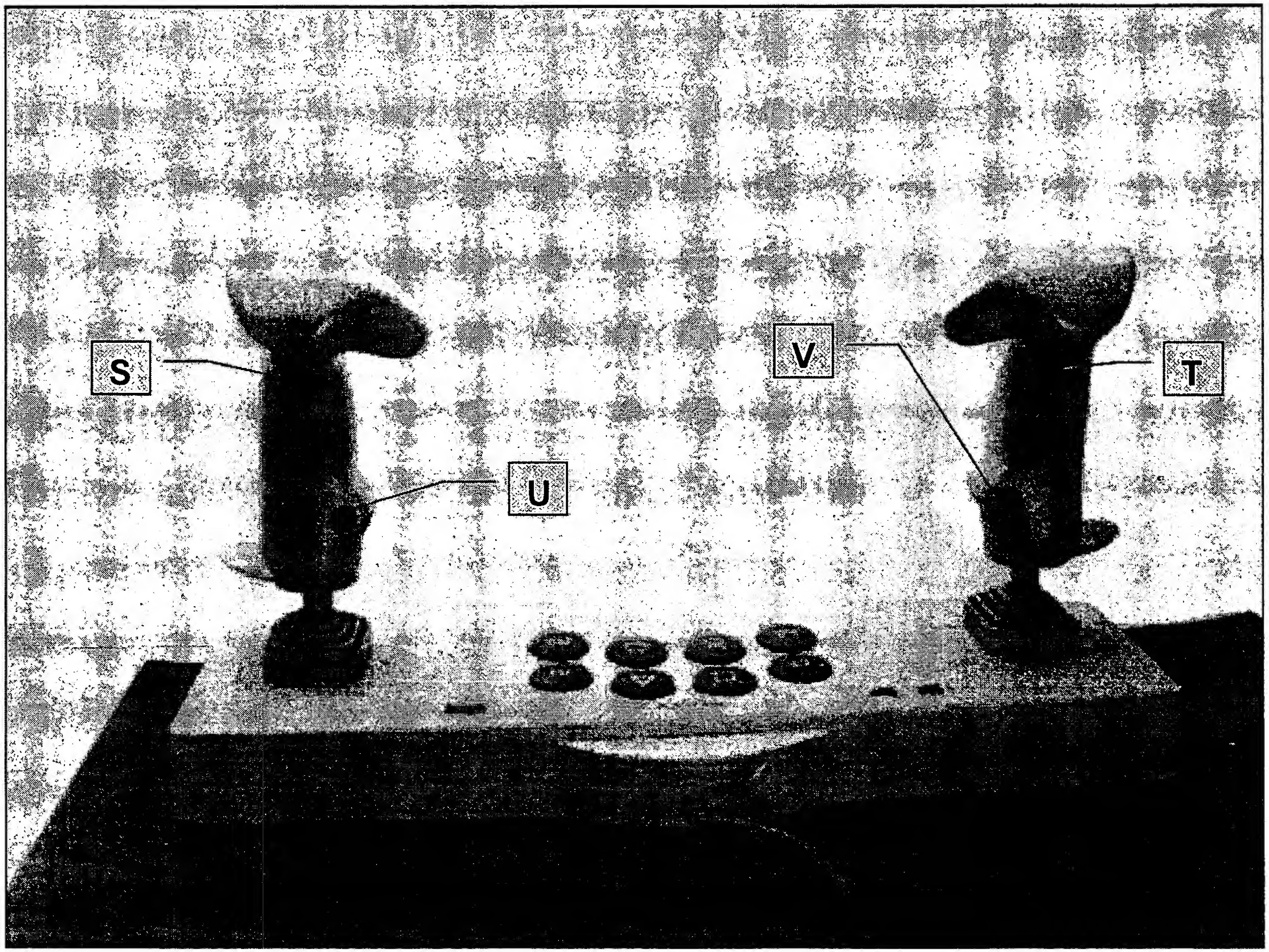

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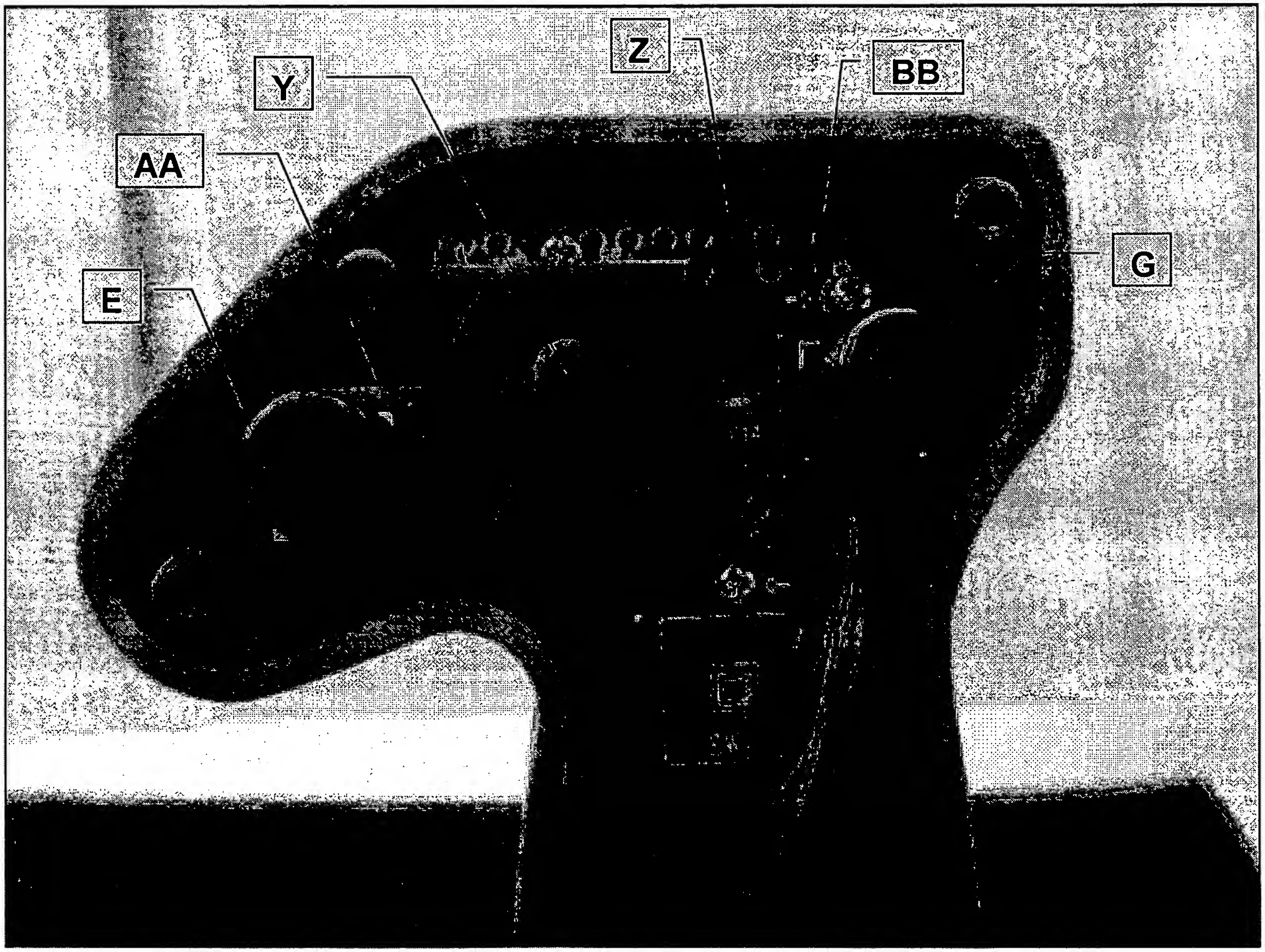

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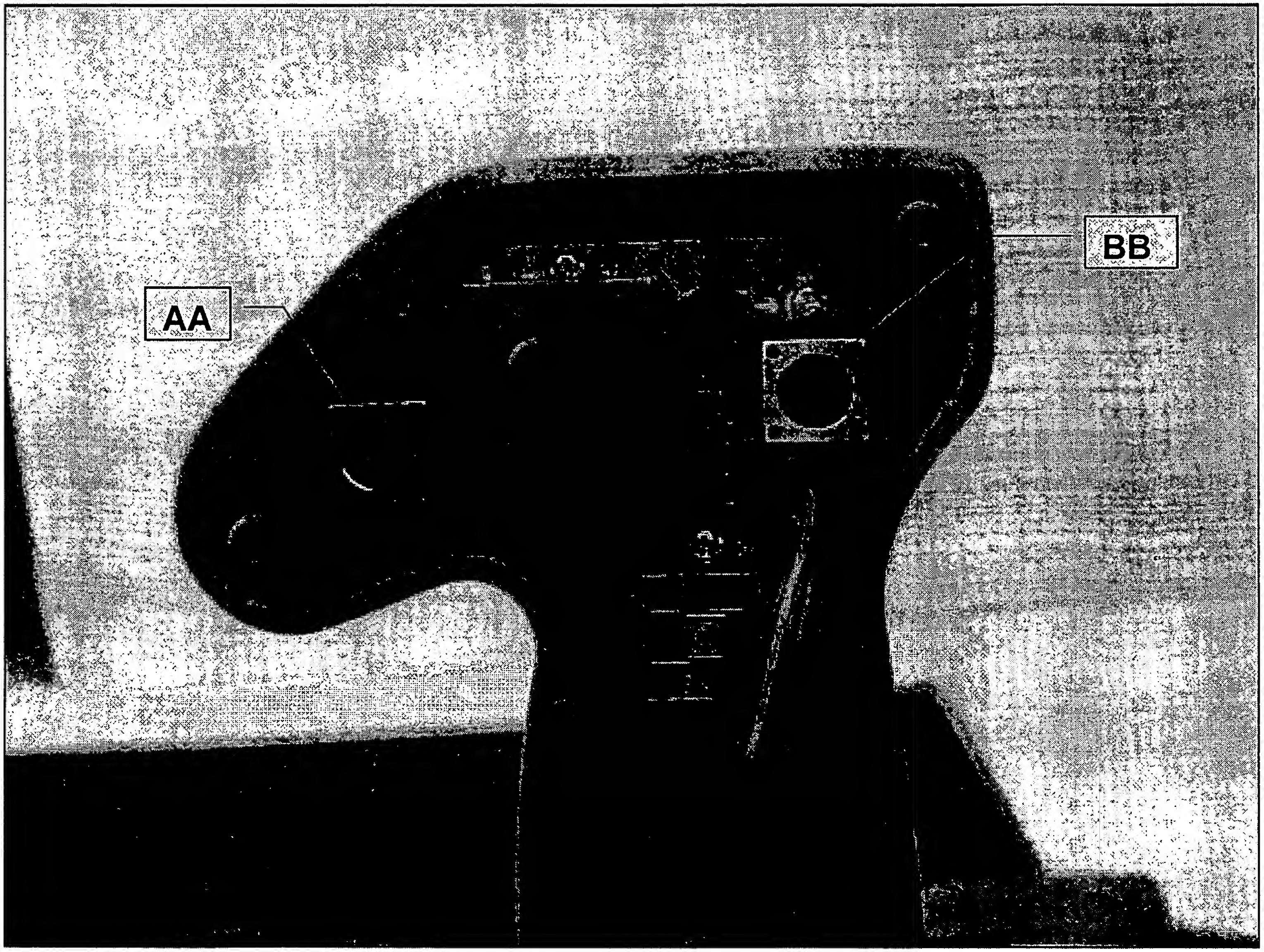

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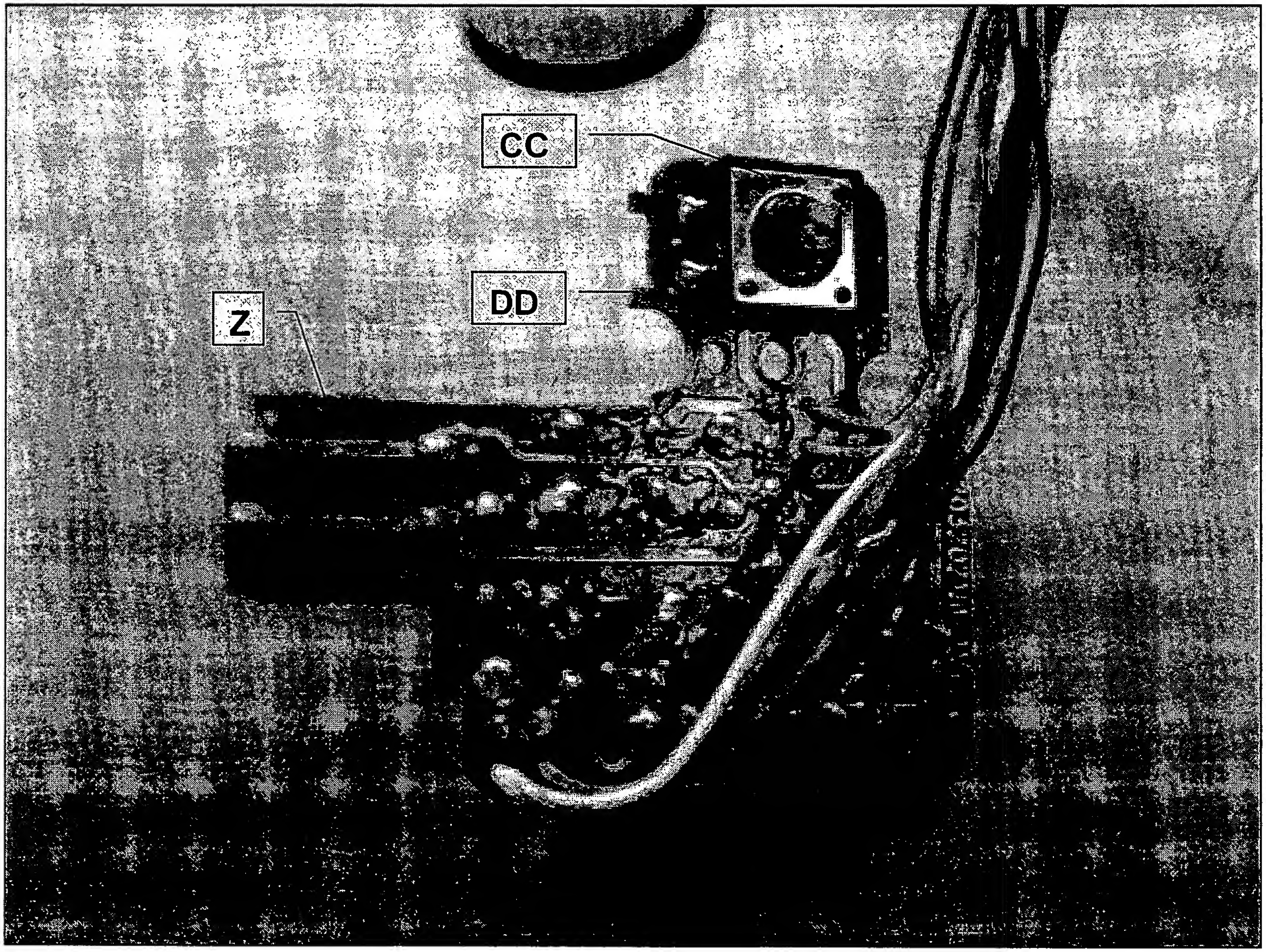

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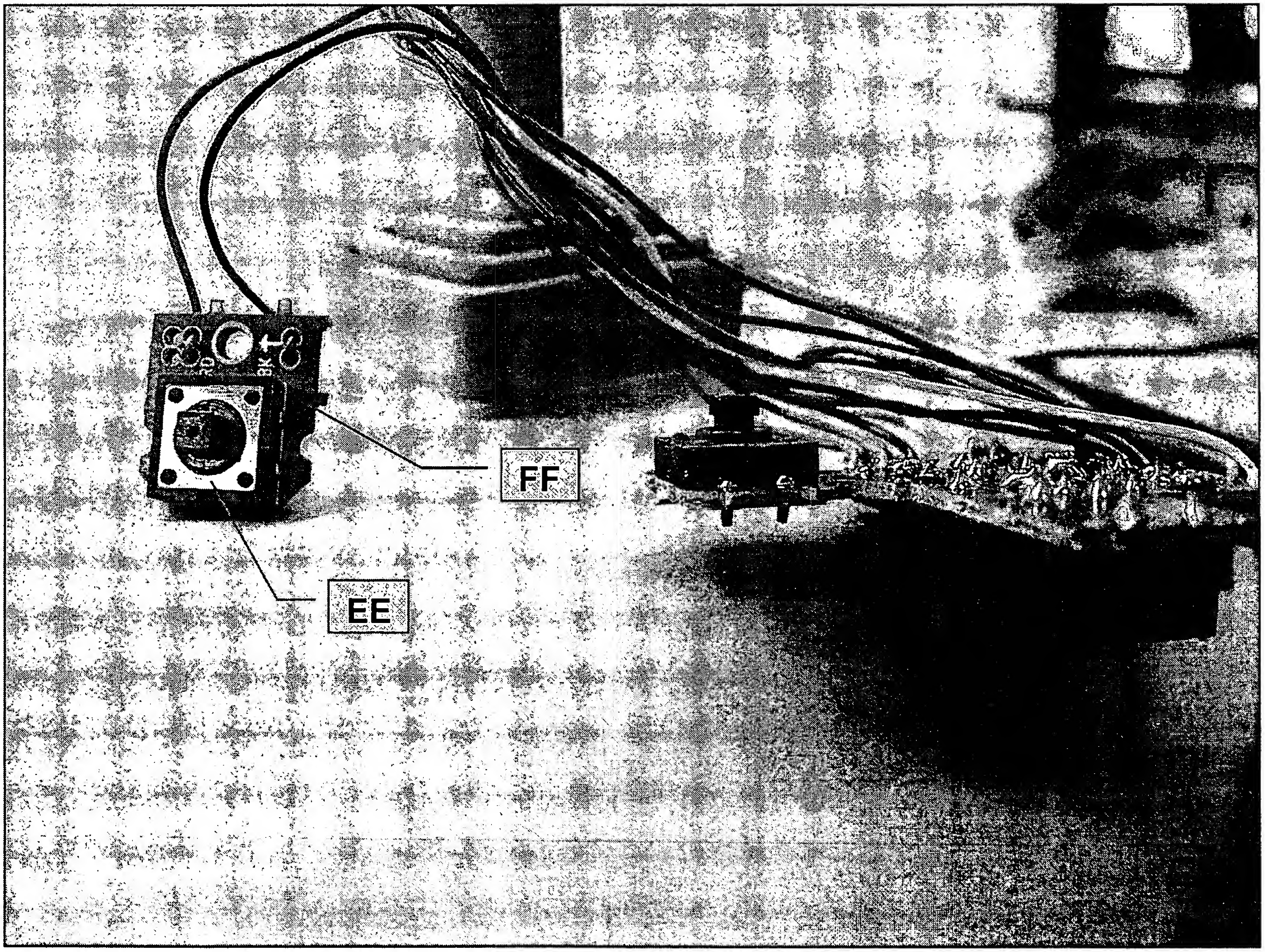

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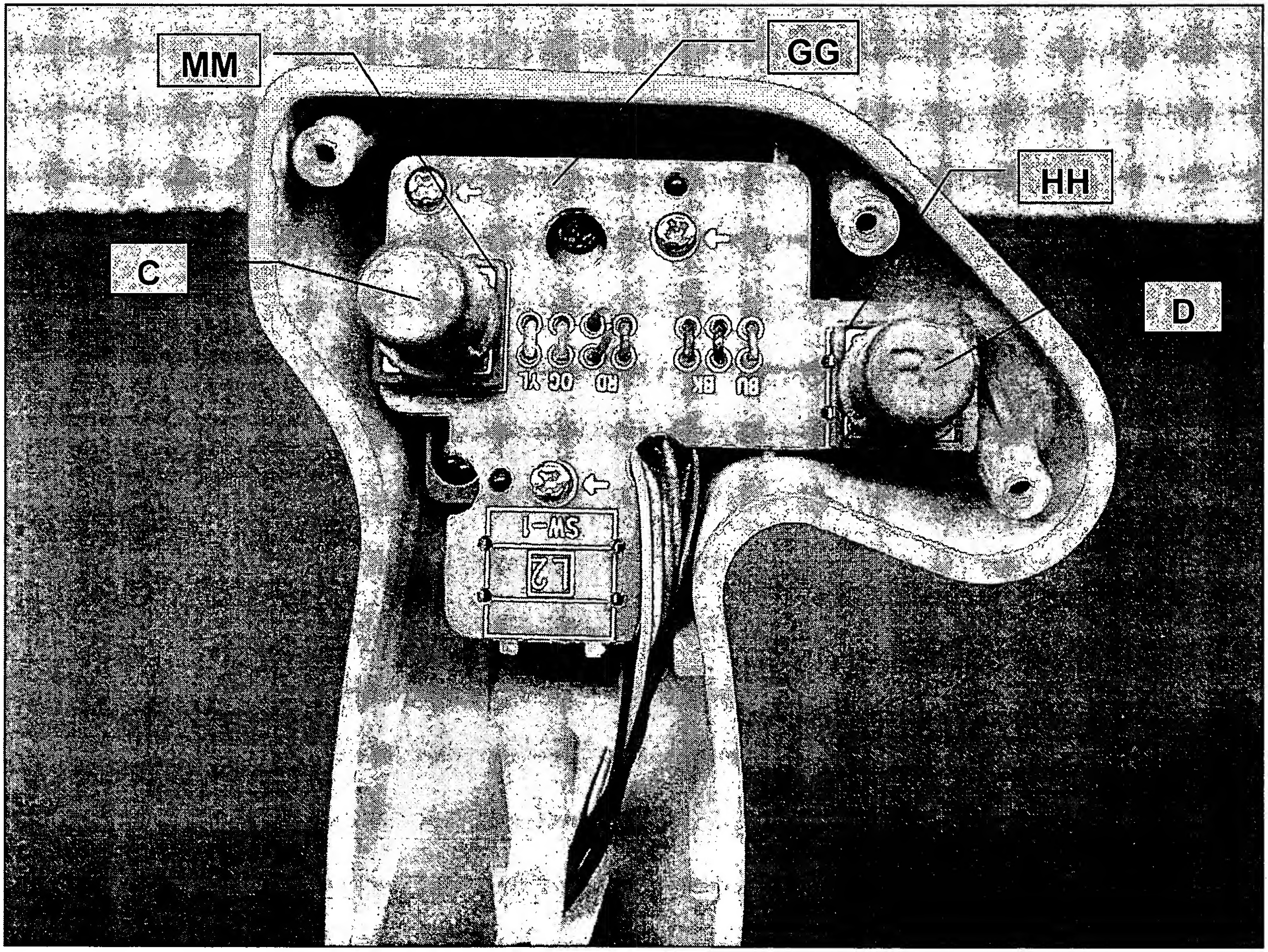

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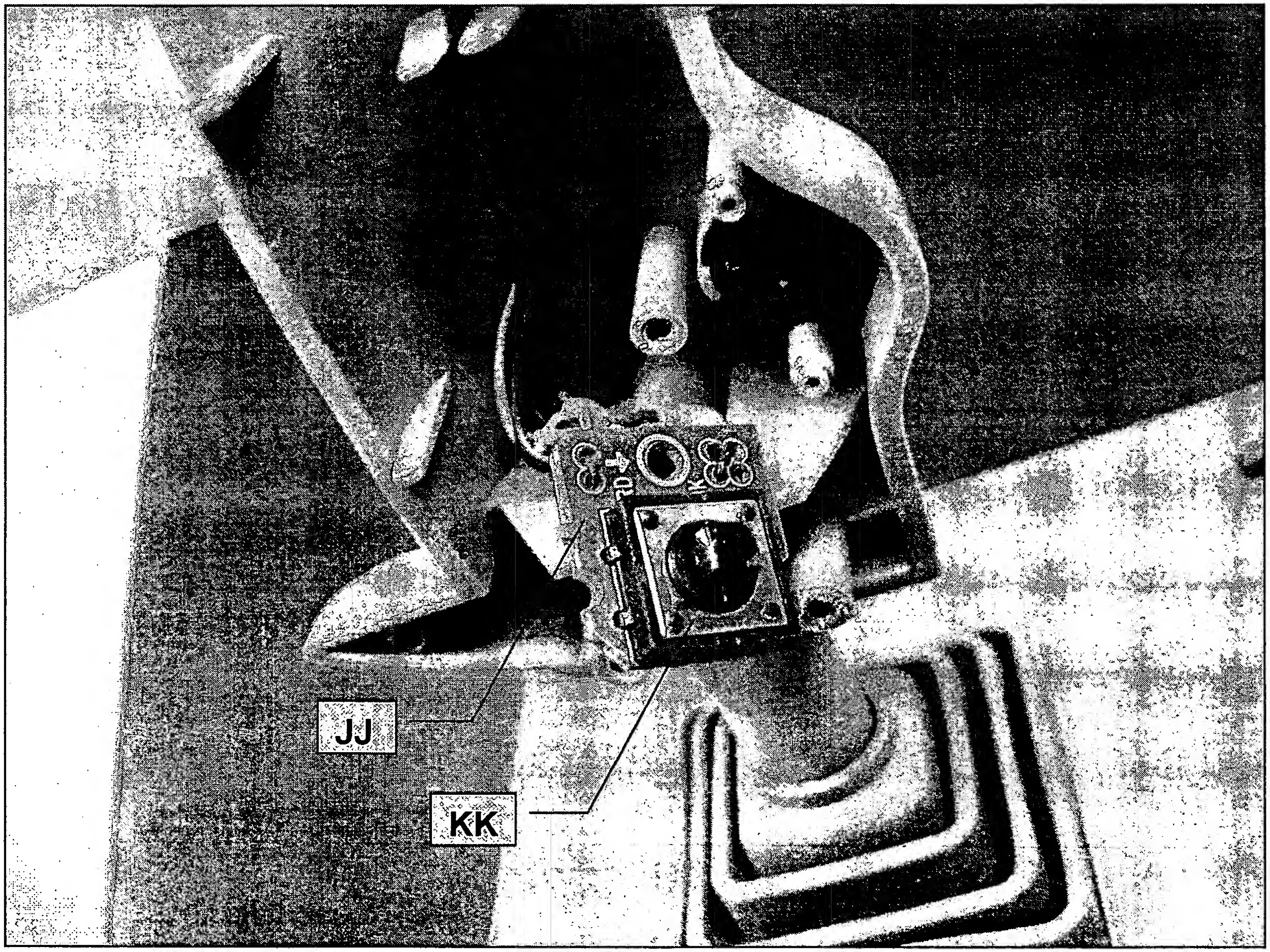

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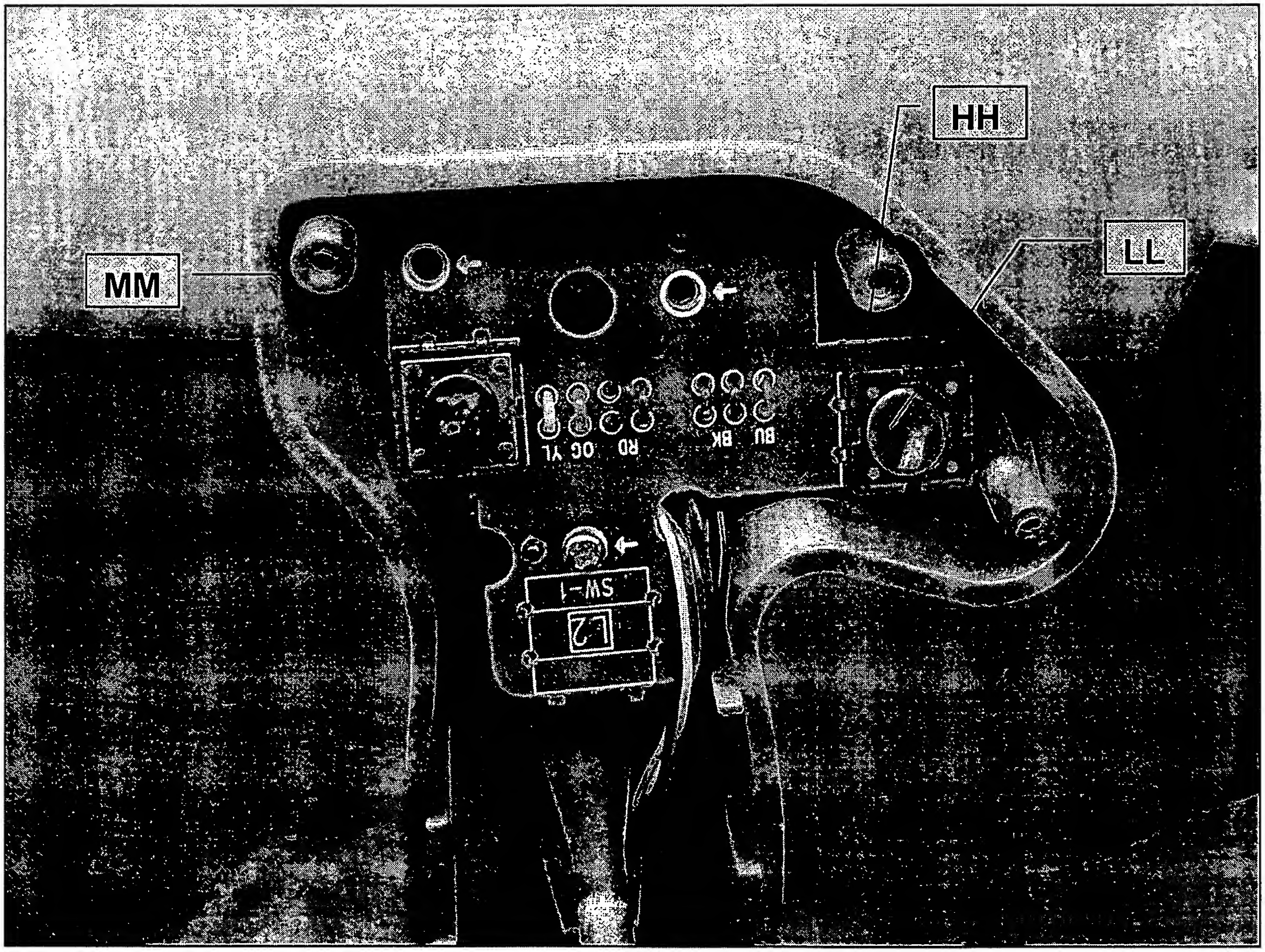

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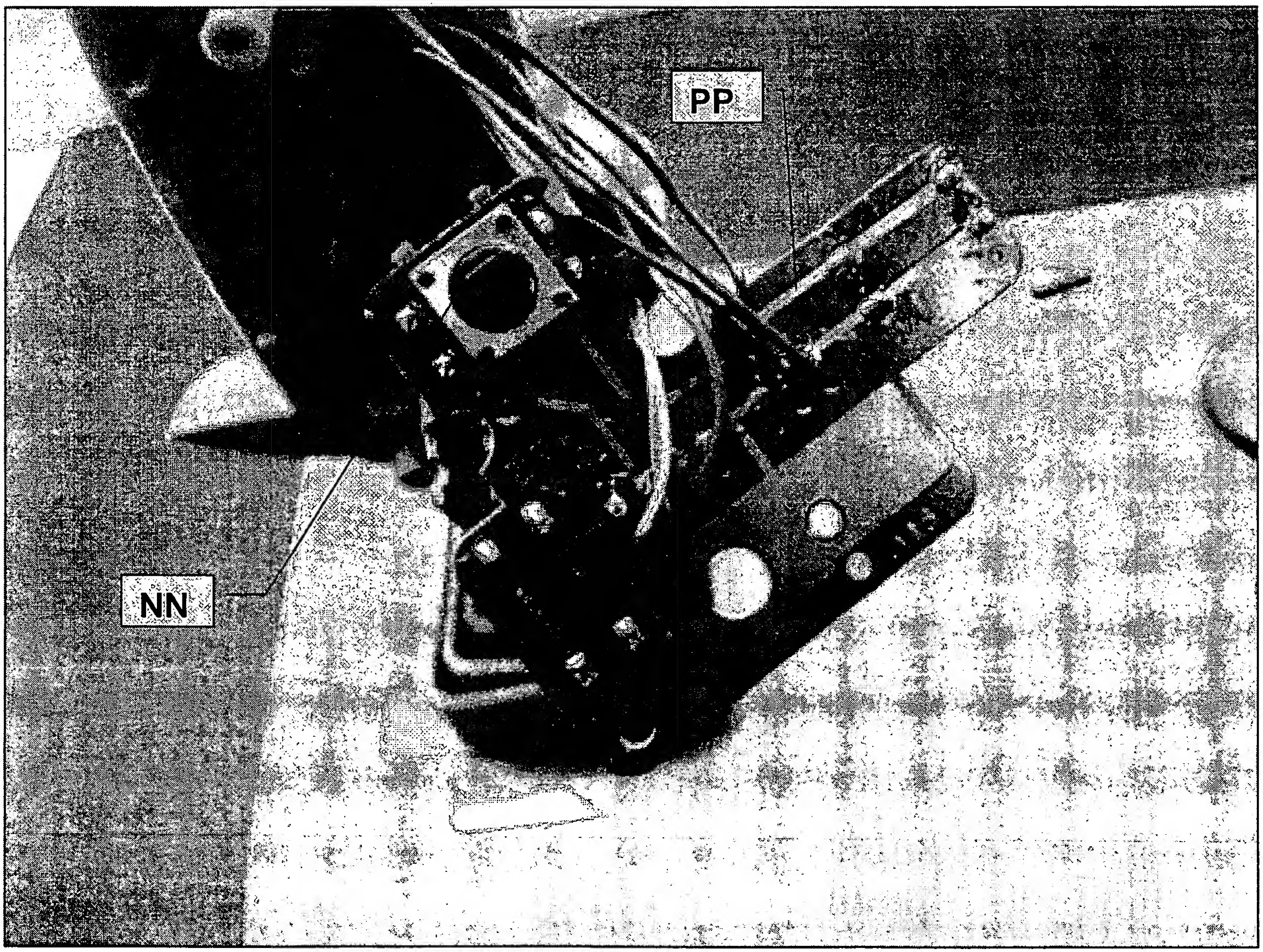

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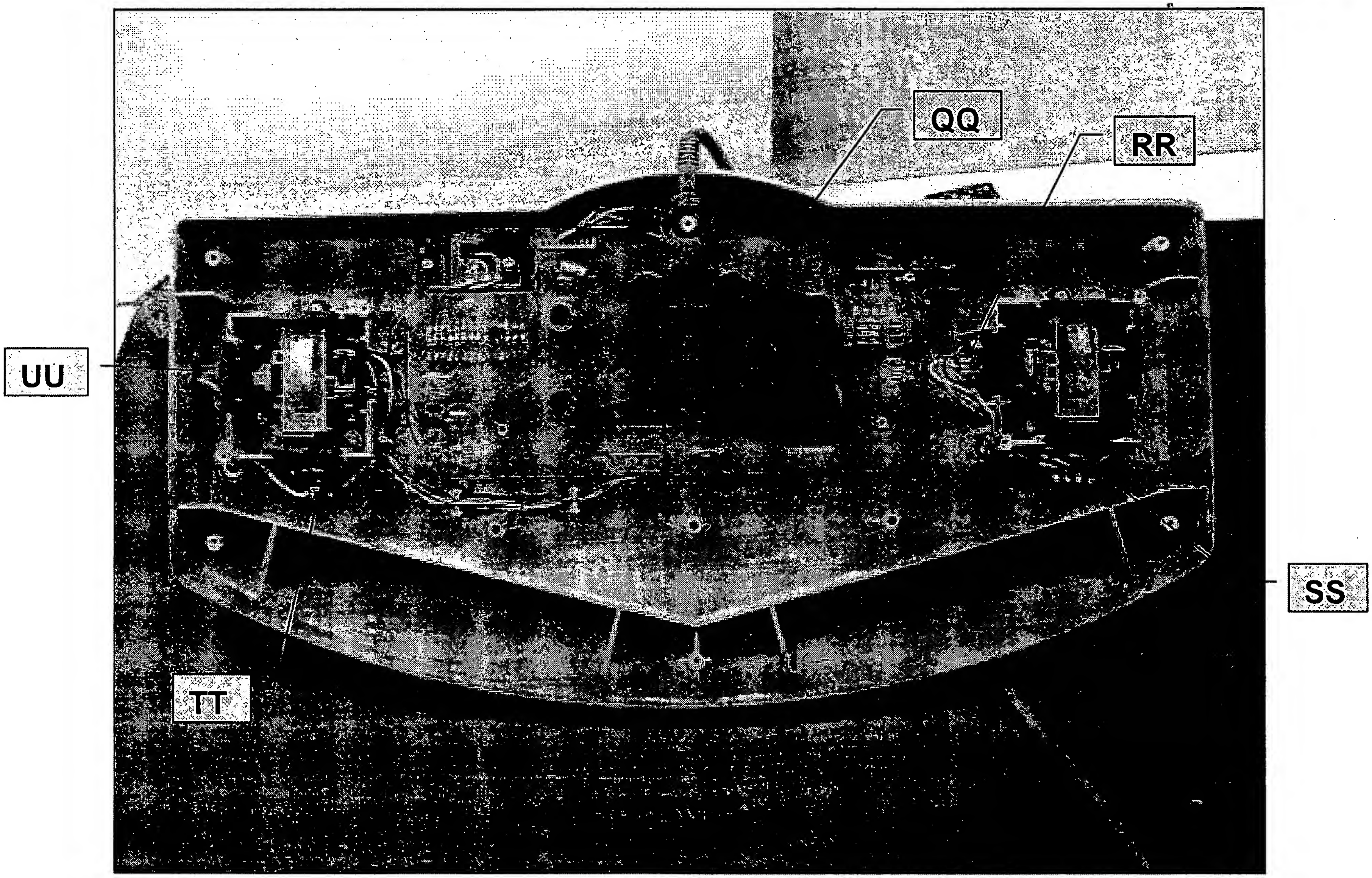

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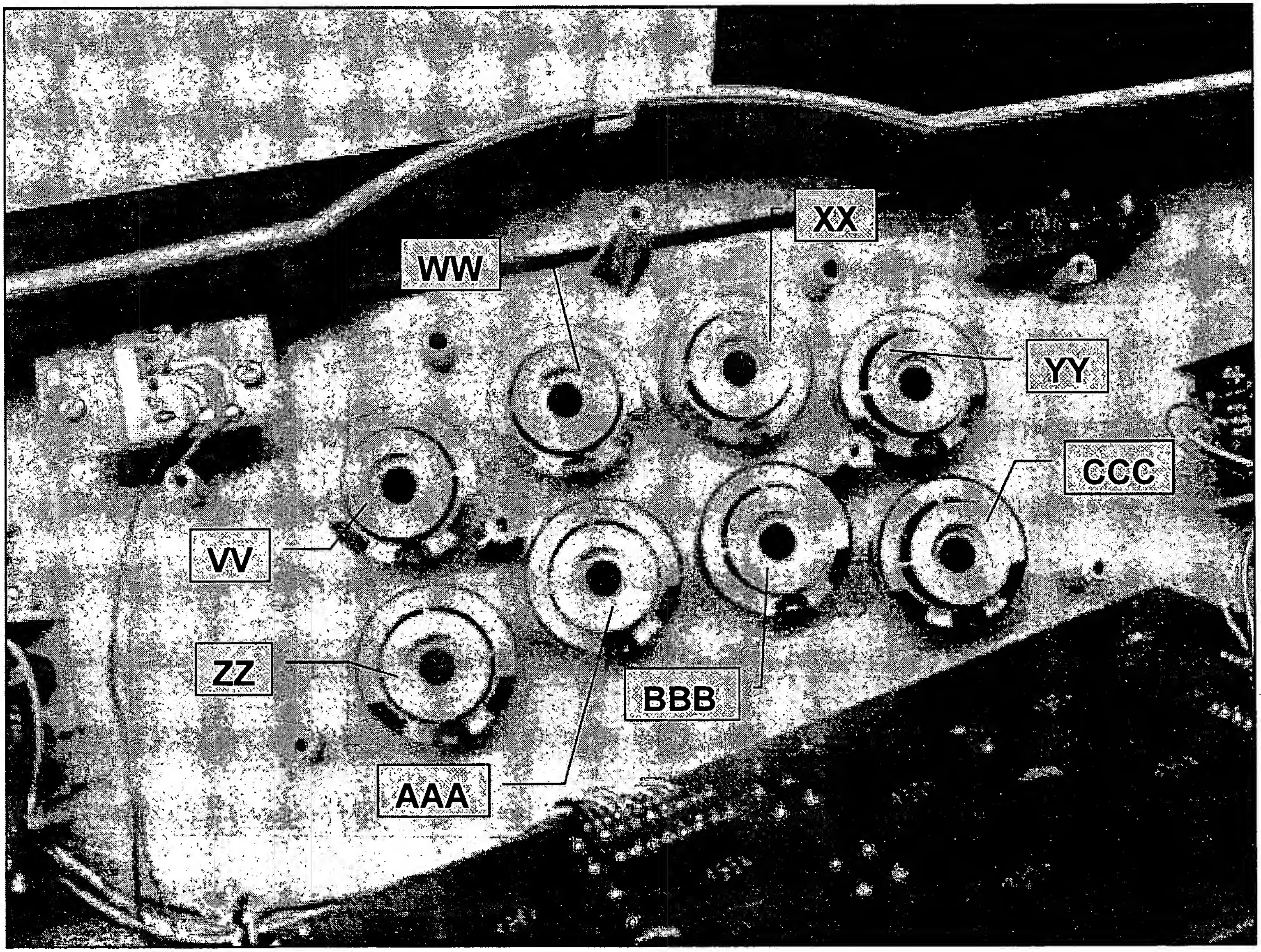

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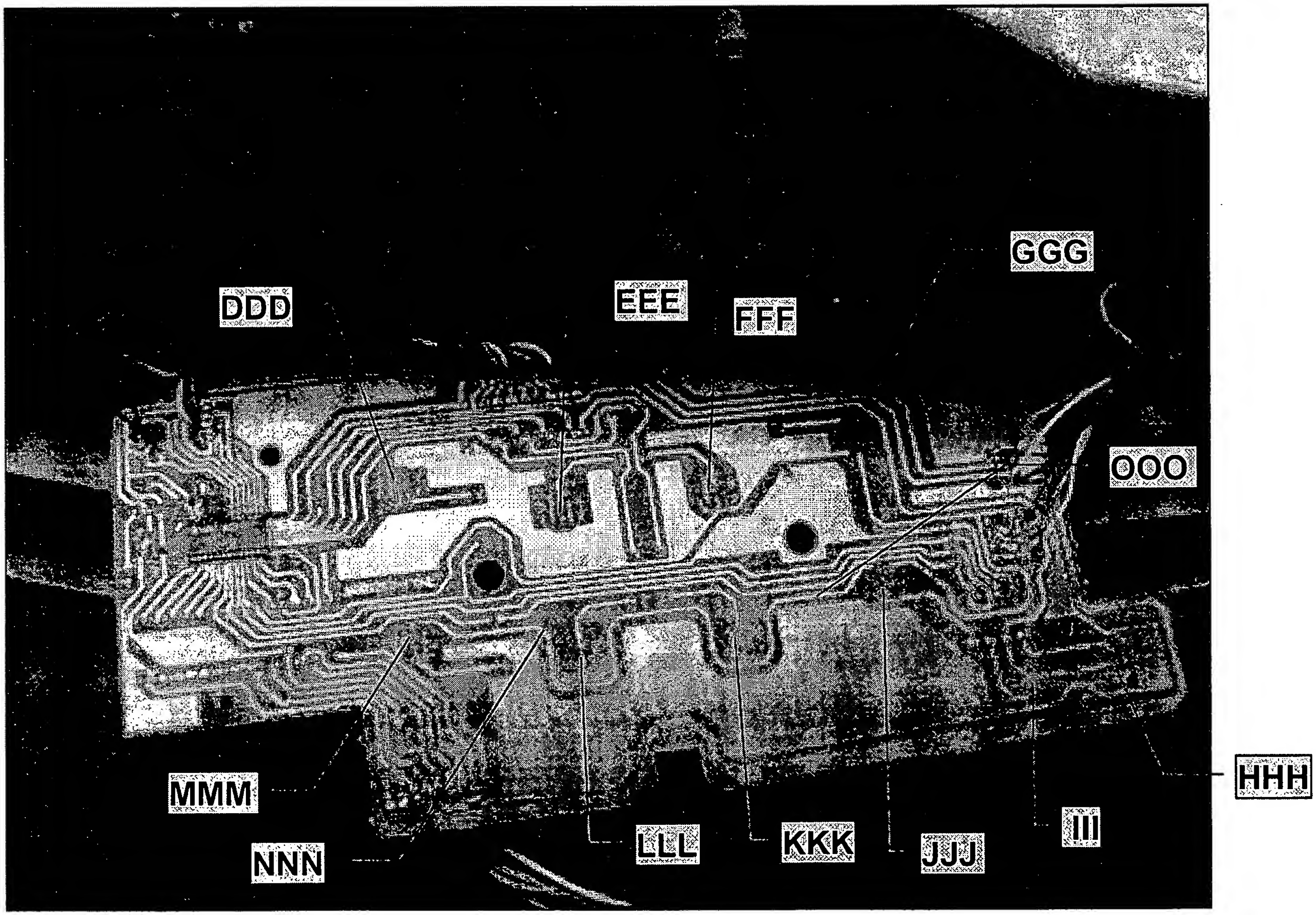

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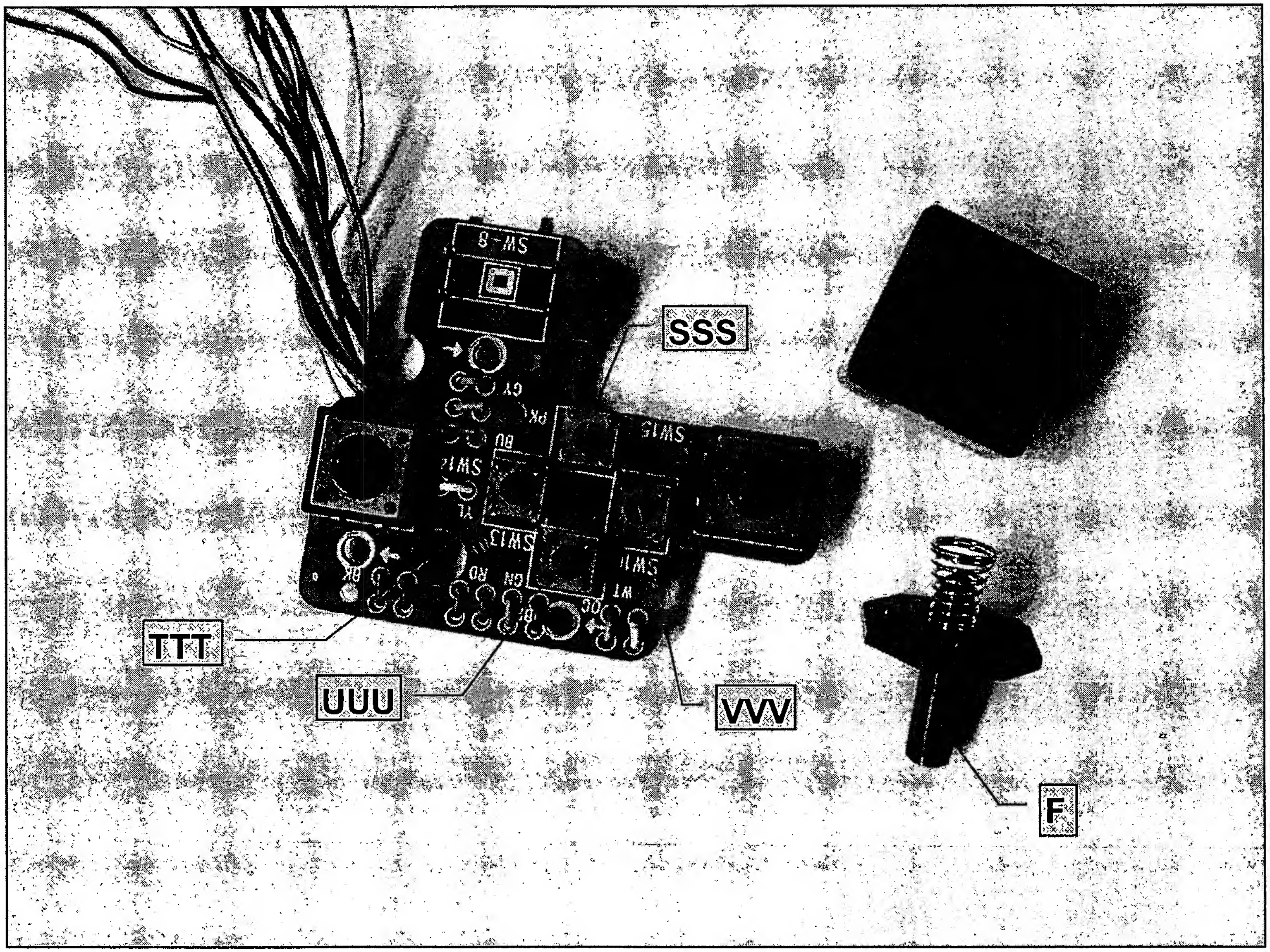

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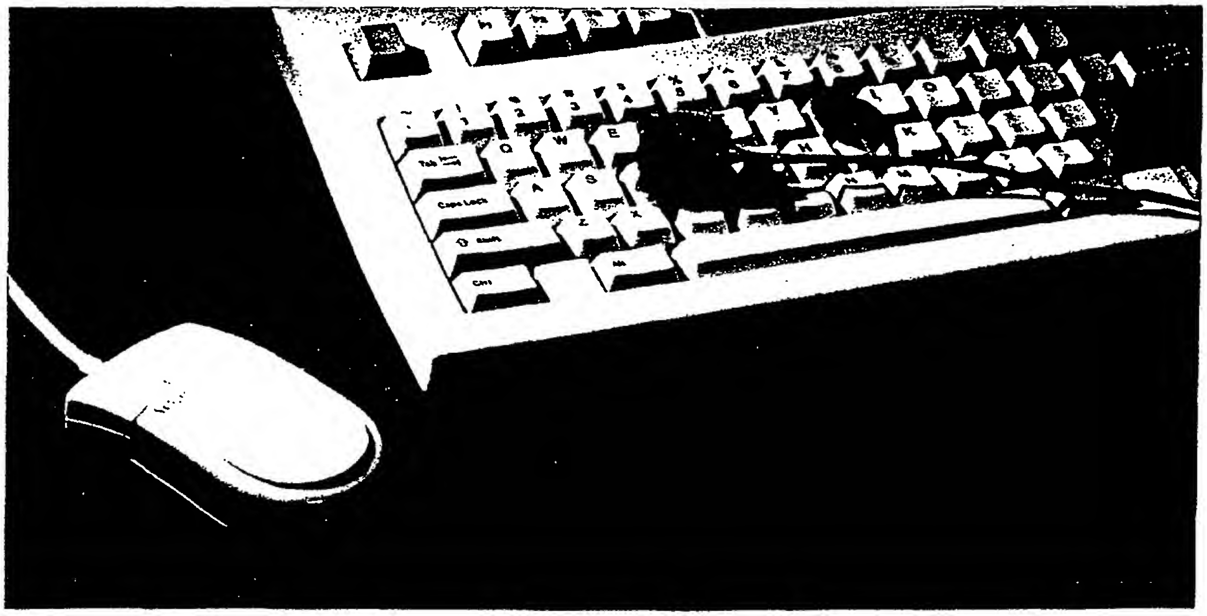

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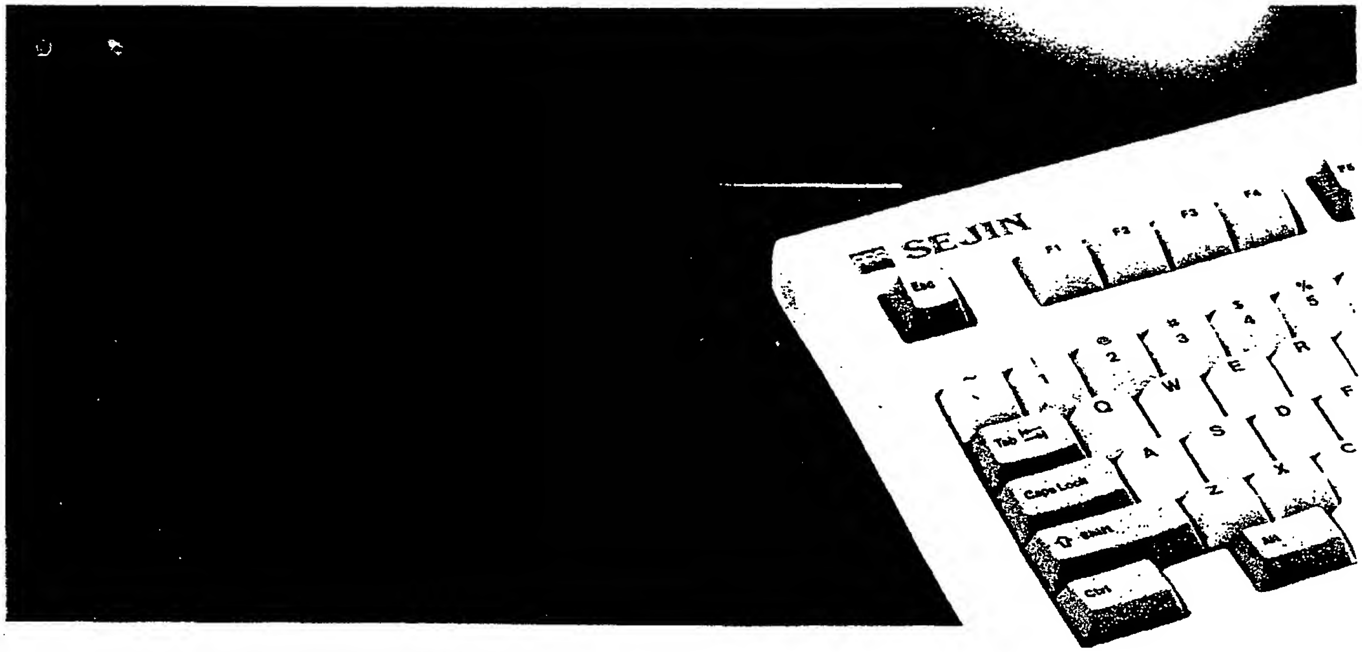

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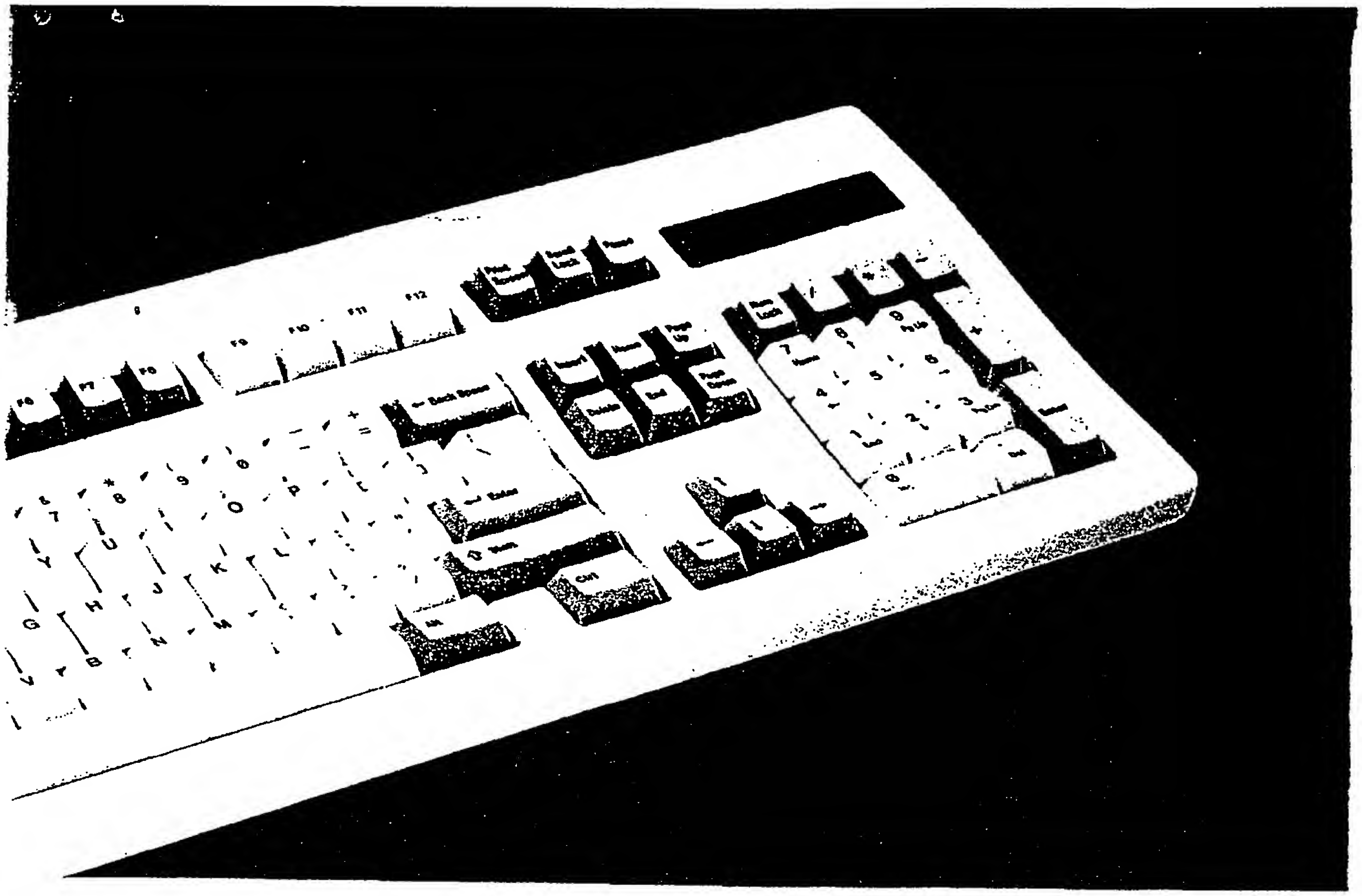

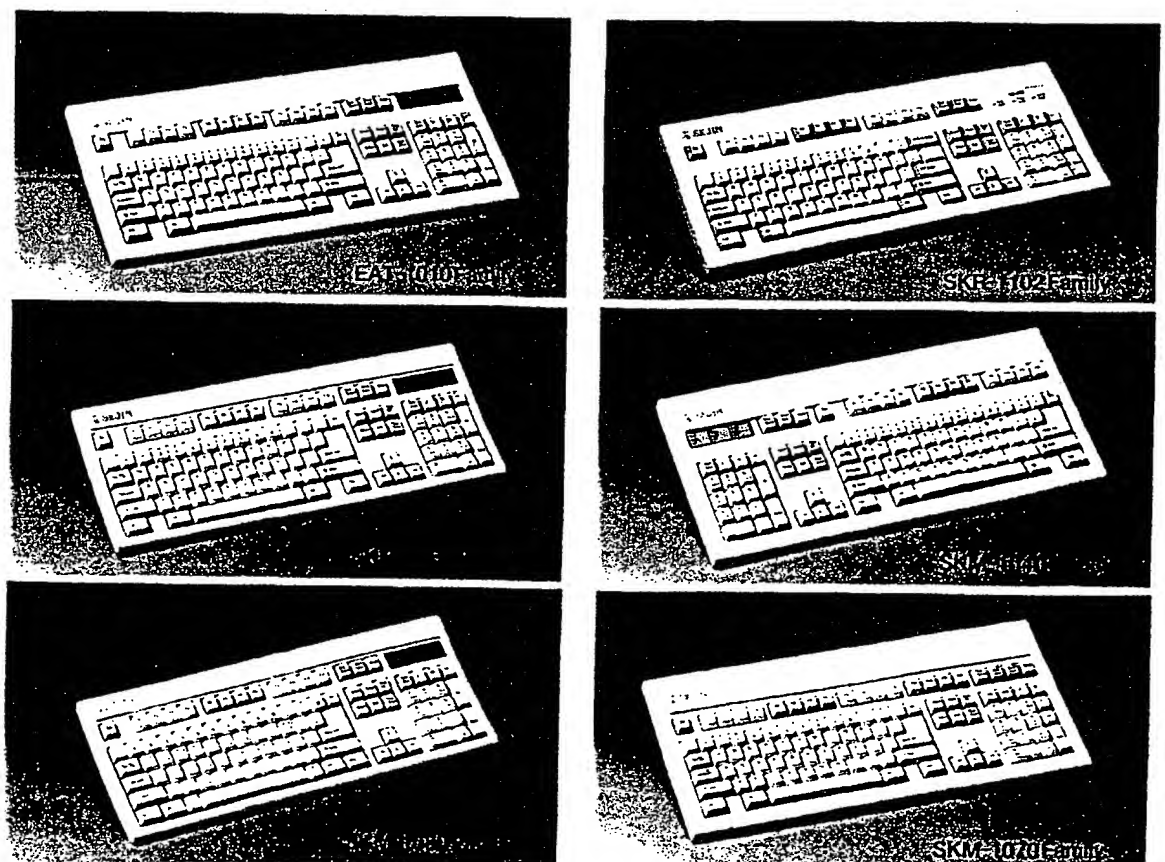

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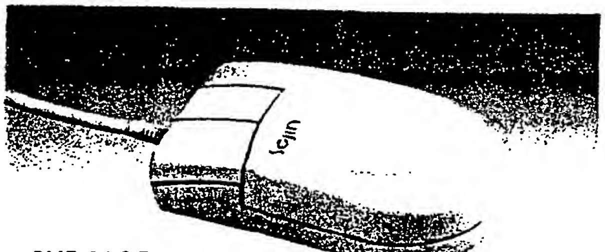
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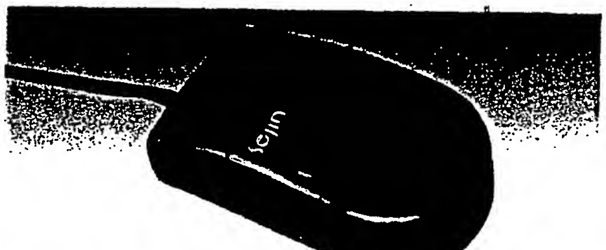
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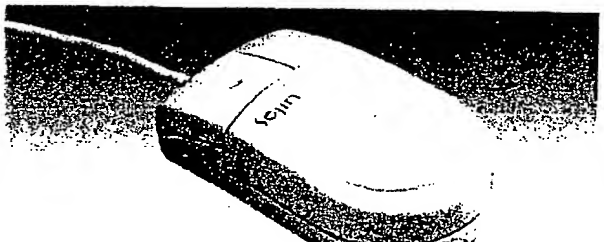
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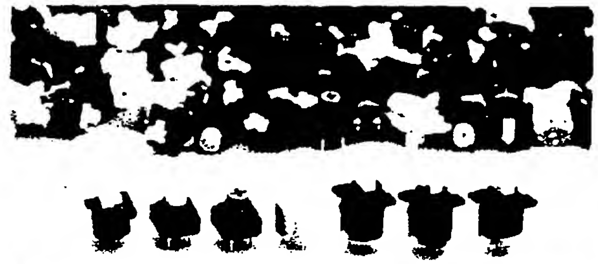

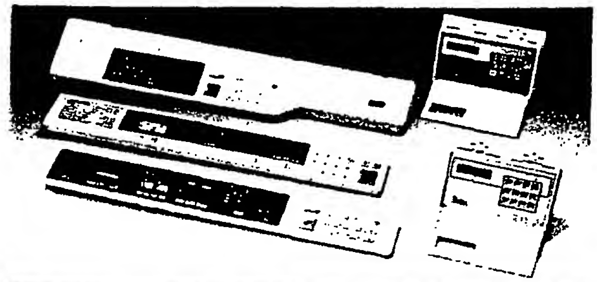

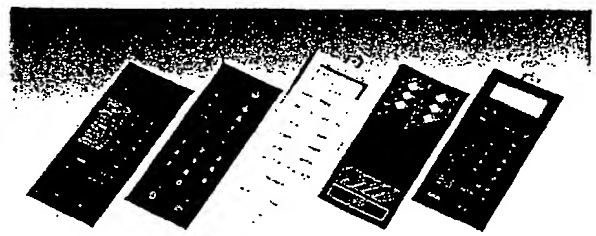

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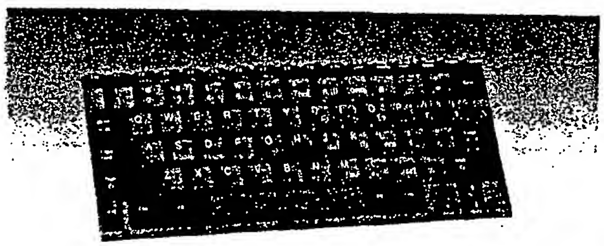
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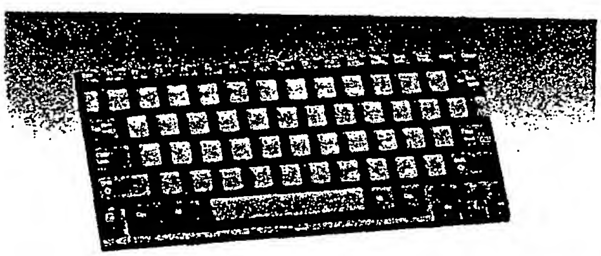
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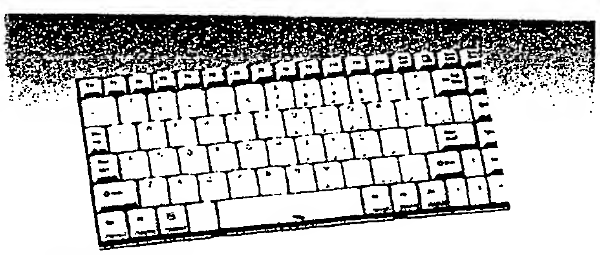
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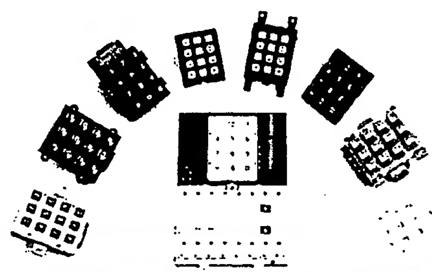

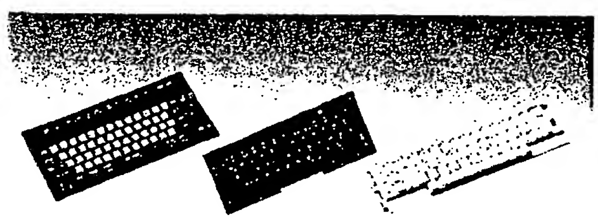

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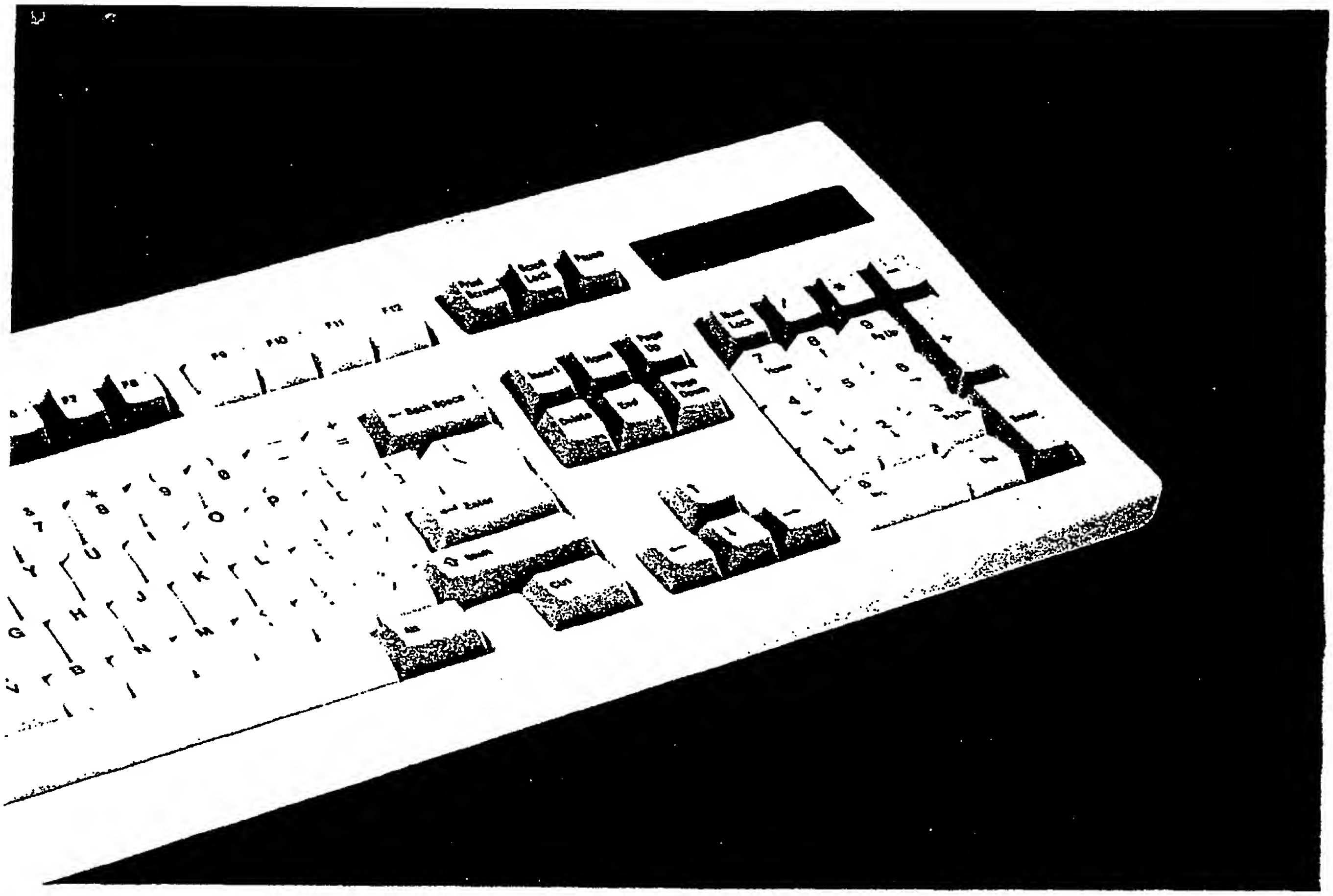

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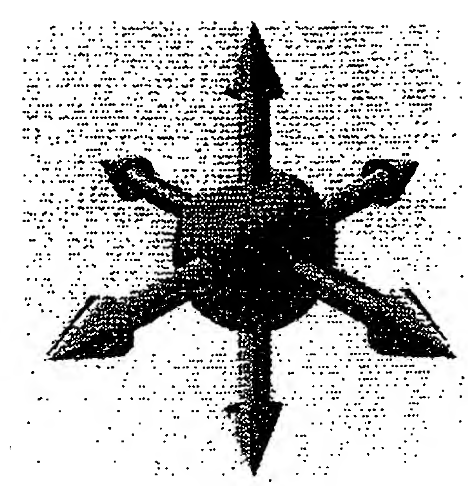

CyberMan 3D Controller Programming Supplement

Version 1.0

(draft 5 - 8/23/93)

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Table of Contents

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Introduction

Purpose

This document is a supplement to the *Logitech Pointing Device Toolkit (or earlier Logitech Mouse Technical Reference & Programming Guide)*, covering those programming issues specific to the Logitech CyberMan™ 3D Controller. Used in conjunction with that toolkit, it should provide software developers all the information they need to effectively support the CyberMan 3D Controller.

Scope

This document focuses on the specific feature set and application programming interface (API) of the CyberMan product. It describes all non-electrical aspects of the programming interface as they appear to an application program. This document does not describe in detail standard mouse API functions that are supported by CyberMan.

Document Organization

This document is composed of the following sections:

Section 1: Introduction

Section 2: Theory of Operation

Section 3: Function Reference

Section 4: Technical Notes

Appendix A: Logitech Developer Support

Section 1 is this Introduction. Section 2 describes the operation and programming model of the CyberMan peripheral, while section 3 is a complete reference to the relevant API functions. Section 4 covers the odd technical detail and some common questions. Appendix A outlines Logitech's developer support plan.

Contents of Toolkit

The CyberMan Programmer's Toolkit consists of this document, and a diskette containing the following files:

MOUSE.COM	CyberWare driver version 6.31
CYBERMAN.H	'C' include file, CyberMan functions
CYBERMAN.C	'C' code for CyberMan functions
TESTDRV.EXE	CyberMan test program

2

Theory of Operation

This section describes the CyberMan peripheral as it appears to a programmer.

CyberMan is an interactive 3-D controller for IBM PC compatible computers. It provides:

- Position information in three dimensions
- Orientation information on three axes
- Three buttons
- Tactile feedback to the user's hand, controlled by the application.

As seen through the driver API, CyberMan is a Logitech 3-button mouse, with additional features and functions. The additional functions are called SWIFT functions, and CyberMan is Logitech's first SWIFT device.

What is SWIFT?

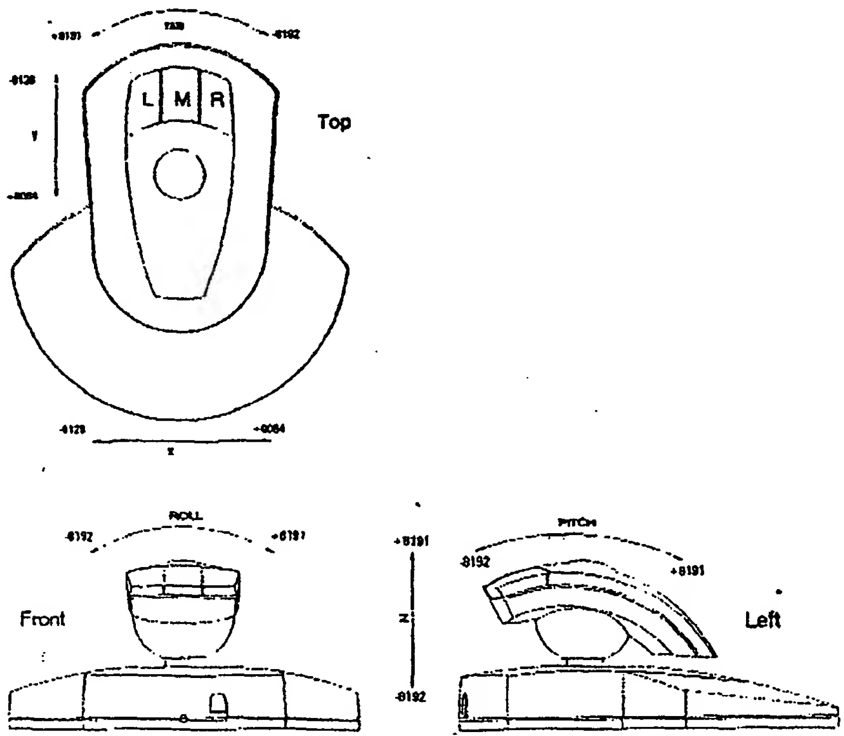
SWIFT: Senseware Interface Technology.

SWIFT devices are devices that give senses to the computer or output sensory feedback to the user via computer control. Currently the only SWIFT device is the Logitech CyberMan. In the future, other SWIFT devices may include different input devices (joysticks, 2D mice, 3D mice), tactile feedback units, visual display systems, temperature sensing devices, external robots, etc.

SWIFT Functions are functions provided by Logitech's software mouse driver, starting with CyberWare 6.31. These are additional functions beyond the standard mouse functions that are supported if and only if a **Senseware Interface Technology (SWIFT) device, such as CyberMan, is connected to the host computer upon initial loading of the mouse driver. Since these are additional functions, all standard mouse driver functions are also supported in CyberWare 6.31.**

Note: SWIFT is a growing specification. If any individual or company would like to add additional devices or commands to the SWIFT specification, please contact Logitech Developer Relations - contact information is in Appendix A.

Device Model



CyberMan

The following table summarizes the application-visible attributes or properties of the CyberMan controller. Each attribute is discussed in more detail below.

CyberMan Programming Attributes

Attribute	Type or Range	Access	Function #
x, y position	-8192..+8191 (notes 0, 1)	read	01h, C0h
z position	-8192..+8191 (note 2)	read	01h, C0h
pitch, roll, yaw angle	-8192..+8191 (note 3)	read	01h, C0h
L, M, R button state	boolean (0, 1)	read	01h, C0h
cursor x, y position	-32768..32767 (note 4)	read/set (note 5)	C0h
external power connected	boolean (0, 1)	read	C2h, C0h
external power overvoltage	boolean (0, 1)	read	C2h, C0h
tactile burst duration	0..10200 ms	set	30h
tactile burst on and off times	5..1275 ms	set	30h
event handler event mask	32-bit mask	read/set	C0h
event handler subroutine	32-bit subroutine address	read/set	C0h
event handler data buffer	32-bit buffer address	read/set	C0h
device type	0..255 (note 6)	read	C1h
device version - major	0..255	read	C1h
device version - minor	0..99	read	C1h
relative/absolute flags	1 bit per coordinate	read	C1h
return-to-center flags	1 bit per coordinate	read	C1h
coordinate resolution	4 bits per coordinate	read	C1h

note 0: The data ranges for CyberMan position and orientation values are -8192 to +8191. *This does not imply that CyberMan will generate all possible values in this range.* Any version of CyberMan, and any other SWIFT device, will map the full range of physical device motion into approximately this range, with varying resolution. The following notes give specific mappings for CyberMan.

note 1: There are 254 distinct X and Y values, from -8128 to +8064, in increments of 64.

note 2: Z position has 3 values: -8192, 0, and +8191

note 3: Pitch, Roll and Yaw have 3 values: -8192, 0, and +8191.

note 4: This is the same as the normal mouse cursor position i.e. reading this attribute through the standard mouse driver function 3 will give the same value. The x and y values are integers with (0, 0) being the upper-left pixel of the screen.

note 5: There is no SWIFT function to set the cursor position, but the standard mouse driver function 4 can be used.

note 6: 0 = No SWIFT device attached. 1 = CyberMan attached. 2..255 are reserved for future devices.

CyberMan SWIFT Functions

The following table shows the SWIFT functions that apply to CyberMan. All functions can be invoked by placing the function number in register AL, the value 53h ('S') in AH, and executing an INT 33h. Alternatively, the CyberMan Programmer's Toolkit contains a small linkable module, CYBERMAN.C, that defines C-callable routines for each of the SWIFT functions. By compiling and linking this module into your program, and including the CYBERMAN.H header file into your calling modules, you can employ this more convenient interface to the CyberMan controller.

CyberMan SWIFT Functions

C Function	Description
SWIFT_Get3DStatus()	get absolute 3D position, orientation, and button status
SWIFT_TactileFeedback()	program tactile feedback feature
SWIFT_ExchangeEventHandler()	set event handler, get previous event handler
SWIFT_GetStaticDeviceInfo()	get SWIFT Static Device Data and Driver Support Status
SWIFT_GetDynamicDeviceData()	get SWIFT Dynamic Device Data
SWIFT_IsCyberManPresent()	test specifically for CyberMan attached

If an application attempts to call a SWIFT Function in a Logitech mouse driver prior to version 6.31, or a Microsoft or other mouse driver, the driver will ignore the call and return to the application without altering the contents of the AX, BX, CX, or DX registers.

3

Function Reference

Function 0Ch - Install Event Handler

Note: This is a standard mouse driver function, available in all Microsoft-compatible DOS mouse drivers - but the standard behavior of this function is extended for SWIFT devices. The following description applies *only if* the CyberWare driver is loaded, has detected a CyberMan or equivalent SWIFT device, *and the application has invoked SWIFT Function 53C1h*. These restrictions ensure that existing applications that use Function 0Ch and Function 14h are not affected.

This function sets the address of a user subroutine, called an 'event handler', that the mouse driver calls when specified events occur. When one of the specified events occurs, the driver temporarily stops execution of the main program (as with any interrupt) and calls the event handler.

See also Function 14h below - we recommend that you use Function 14h instead of Function 0Ch, if possible, because it can be used to restore a prior event handler when your application terminates.

Input:

AX = 000Ch
CX = event mask (see below)
ES:DX = address of event handler subroutine

Output

none.

Setting the event mask to 0 disables the event handler.

Event Mask

Mask Bit	Condition
0	mouse cursor position changed
1	left button pressed
2	left button released
3	right button pressed
4	right button released
5	middle button pressed
6	middle button released
7	other button pressed
8	other button released
9	X coordinate changed
10	Y coordinate changed
11	Z coordinate changed
12	Pitch value changed
13	Roll value changed
14	Yaw value changed
15	'other' condition - including device status changed

The event handler is called from the mouse driver during the handling of a mouse hardware interrupt. This means the event handler must work under the same assumptions as any other interrupt handling code. For example, it is usually not possible or advisable to call DOS from the event handler. Is is also strongly recommended to spend as little time as possible in the event handler.

The recommend procedure for an event handler is to record the event in a queue to be read by the main program. In this way, mouse events can be treated at the same level as keyboard input.

When the event handler is called (via a far call), the following information is available in these registers:

AX	= event bits (same format as event mask above)
BX	= button status (bit 0: left, bit 1: right, bit 2: middle)
CX	= horizontal (X) cursor position (not device X coordinate!)
DX	= vertical (Y) cursor position (not device Y coordinate)
SI	= paragraph address of extended information block (see below)
DI	= undefined.
SS:SP	= the stack of the mouse driver, or of another application - do not expect to use significant amounts of stack space.
DS	= data segment of the mouse driver - your event handler should save and load it appropriately, and restore it before returning.

Event Handler Extended Information

Word 0	X coordinate value
Word 1	Y coordinate value
Word 2	Z coordinate value
Word 3	Pitch value
Word 4	Roll value
Word 5	Yaw value
Word 6	Button Status Word
Word 7	device-specific Dynamic Device Data Word

See Function 5301h for a description of the coordinates and button status word, and see Function 53C2h for a description of the dynamic device data word. Note that the interpretation of the dynamic device data word is device-specific: It has the meaning described in this document only if a CyberMan or CyberMan-compatible device is active.

If you use this function via the C-language interface *SWIFT_ExchangeEventHandler*, provided in the CyberMan Programming Toolkit, you need not worry about the low-level details of the event handler. Read the CYBERMAN.H file to see how information is conveyed to the event handling routine.

Function 14h - Exchange Event Handlers

Note: This is a standard mouse driver function, available in all Microsoft-compatible DOS mouse drivers - but the standard behavior of this function is extended for SWIFT devices. The following description applies *only if* the CyberWare driver is loaded, has detected a CyberMan or equivalent SWIFT device, *and the application has invoked SWIFT Function 53C1h*. These restrictions ensure that existing applications that use Function 0Ch and Function 14h are not affected.

This function temporarily substitutes a new event handler for the currently active one, if any. See Function 0Ch above for a description of event handlers.

Recommended practice is to use Function 14h during initialization of your program, saving the previous event mask and handler. At termination of your program, use Function 14h or Function 0Ch to restore the previous event mask and handler.

Input:

AX	= 0014h
CX	= new event mask (same as Function 0Ch)
ES:DX	= address of new event handler

Output

CX	= previous event mask (set by previous Function 0Ch or Function 14h)
ES:DX	= address of previous event handler

Setting the event mask to 0 disables the event handler.

Function 5301h - Get Position, Orientation, and Button Data

This function returns the SWIFT device's current 3D position data, orientation data, and button status.

Input:

AX = 5301h
ES:DX = Address of status buffer

Output

ES:DX is unchanged.

Position, Orientation, and Button Data Structure Format

Word 0	X position
Word 1	Y position
Word 2	Z position
Word 3	Pitch value
Word 4	Roll value
Word 5	Yaw value
Word 6	Button Status Word

Button Status Word

Bit 0	Right button (1 = Pressed)
Bit 1	Middle button (1 = Pressed)
Bit 2	Left button (1 = Pressed)
Bit 3	Button 4
Bit 4	Button 5
Bit 5	Button 6
Bit 6	Button 7
Bit 7-15	Reserved

Function 5330h - Program Tactile Feedback

This function activates the tactile feedback feature of the SWIFT device.

Input

AX	= 5330h
BH	= motor on time, in units of 5 ms
BL	= motor off time, in units of 5 ms
CL	= tactile burst duration, in units of 40 ms

Output

None

This function begins or ends a 'burst' of tactile feedback. Any tactile burst in progress from a previous call to this function is cancelled. If duration (CL) > 0, the new burst begins immediately and lasts for CL*40 milliseconds. If CL is 0, any prior tactile burst is terminated, and no new burst is started.

A tactile burst consists of repeated On/Off cycles - the tactile feedback motor is turned on for BH*5 ms, then turned off for BL*5 ms, repeating for the duration of the burst.

A value of 0 in BL or BH is interpreted to mean '5 ms'.

Maximum tactile burst duration:	10.2 s (255 * 40 ms)
Maximum 'on' time per cycle:	1.275 s (255 * 5 ms)
Maximum 'off' time per cycle:	1.275 s (255 * 5 ms)
Minimum on or off time per cycle:	5 ms

NOTES:

Use tactile sparingly - if it is used too much, users may become desensitized (or annoyed). We suggest that you allow tactile feedback to be disabled, for those users who find it objectionable.

The tactile motor is the only reason the CyberMan controller needs external power or batteries. The unit is functional in every other respect without them. This means that tactile feedback is the sole cause of battery drain, when batteries are the active power source.

Function 53C0h - Install SWIFT Event Handler

This function sets the address of a user subroutine to be called by the CyberWare 6.31 driver whenever any of a set of events occurs. The subroutine is called an *Event Handler*. The events of interest are represented by a '1' in the Call Mask. When one or more of the events defined by the call mask occur, the driver temporarily stops execution of your main program (as with any interrupt) and calls the event handler.

This function is a superset of the standard mouse driver functions Install Event Handler (Function 0Ch) and Exchange Event Handlers (Function 14h). Calling any of these functions will supercede any previous call to any of them. In other words, there is only one current Event Handler.

Note: The standard mouse Function 0Ch and Function 14h services can be used with CyberMan - developers with existing code that uses these services, and developers working in protected mode, may find it preferable to use Mouse Function 0Ch or Function 14h for event handling - see the preceding section on these functions as they apply to CyberMan.

Input

AX = 53C0h
ES:DX = Address of Event Handler Setup Data

Output

ES:DX = Address of Previous Event Handler's Setup Data

The event handler is called from the CyberWare 6.31 software driver during the handling of a mouse hardware interrupt. This means the event handler must work under the same assumptions as any other interrupt handling code. For example, it is usually *not* possible or advisable to call DOS from the event handler. It is also strongly recommended to spend as little time as possible in the event handler. The recommended procedure for an event handler is to record the event in a queue monitored by the main program. Then SWIFT events can be treated at the same level as keyboard input.

Setting both call mask words to 0 disables the SWIFT event handler.

Mask words of previous event handler being both 0's indicate that no previous event handler routine is installed.

Event Handler Setup Data

Word 0	Call Mask Word 1
Word 1	Call Mask Word 2
Word 2	Address Offset of Event Handler subroutine
Word 3	Address Segment of Event Handler subroutine
Word 4	Address Offset of Event Data Structure
Word 5	Address Segment of Event Data Structure

Event Handler Call Mask

Word Identifier	Word Mask Bit	Event
Call Mask Word 1	Bit 0	cursor position changed
	Bit 1	left button pressed
	Bit 2	left button released
	Bit 3	right button pressed
	Bit 4	right button released
	Bit 5	middle button pressed
	Bit 6	middle button released
	Bit 7	button #4 pressed
	Bit 8	button #4 released
	Bit 9	button #5 pressed
	Bit 10	button #5 released
	Bit 11	button #6 pressed
	Bit 12	button #6 released
	Bit 13	button #7 pressed
	Bit 14	button #7 released
	Bit 15	Reserved
Call Mask Word 2	Bit 0	X Position changed
	Bit 1	Y Position changed
	Bit 2	Z Position changed
	Bit 3	Pitch changed
	Bit 4	Roll changed
	Bit 5	Yaw changed
	Bit 6	Dynamic Data changed
	Bits 7 - 15	Reserved

When the event handler is called (via a far call), the Event Data Structure is filled in as follows:

SWIFT Event Data Structure

Word 0	X position
Word 1	Y position
Word 2	Z position
Word 3	Pitch value
Word 4	Roll value
Word 5	Yaw value
Word 6	Button Status Word (see Function 1)
Word 7	Dynamic Device Data (see Function C2h)
Word 8	Event bits (same format as Call Mask Word 1)
Word 9	Event bits (same format as Call Mask Word 2)
Word 10	Horizontal (X) cursor position
Word 11	Vertical (Y) cursor position

See Function 5301h(above) for position, orientation, and button status data explanation.

See Function 53C2h (below) for interpretation of the Dynamic Device Data word.

Because the event handler is called from the driver interrupt code, special care must be taken with the stack and data segments. The current stack segment may not be that of your application upon entry to the event handler, so it is important to keep stack usage (e.g. procedure calls) to a minimum inside the handler. Also, the data segment is that of the mouse driver upon entry to the event handler. This is not generally a problem in high level languages, where the compiler adjusts the segment registers. But assembly language programmers should either reference variables using CS (if CS=DS) or set DS to the correct value and restore DS on leaving the handler.

Function 53C1h - Get Static Device Data and Driver Support Status

This function returns the device type and version number of the connected SWIFT device and also informs the application if the installed mouse driver supports SWIFT Function calls.

Input

AX = 53C1h
ES:DX = Address of Static Device Data buffer

Output

AX = Return Status,
1 = Driver supports SWIFT functions
Any other value = SWIFT functions not supported
ES:DX = Buffer address, same as Input

Static Device Data

Byte 0	Device Type
Byte 1	Major Version Number
Byte 2	Minor Version Number
Byte 3	X Coordinate Descriptor
Byte 4	Y Coordinate Descriptor
Byte 5	Z Coordinate Descriptor
Byte 6	Pitch Coordinate Descriptor
Byte 7	Roll Coordinate Descriptor
Byte 8	Yaw Coordinate Descriptor
Byte 9	Reserved

Device Type Encoding:
0 = No SWIFT device connected
1 = Logitech CyberMan connected
2 - 255 Reserved for Logitech SWIFT devices

Major version number (e.g. 1 for version 1.50)
Minor version number (e.g. 50 for version 1.50 or 3 for version 1.03)
(version number of what?)

Coordinate Descriptor

Bit 0-3	Bits of resolution (0..15)
Bit 4	Reserved
Bit 5	Return to Center (1 = return to center)
Bit 6	Absolute/Relative (1 = absolute, 0 = relative)
Bit 7	Reserved

Bits of resolution tells you the number of values or positions that the SWIFT device will distinguish in this coordinate.

Return to Center means that the SWIFT device returns to the 0 position in this coordinate when the user releases the device or stops applying force in this coordinate.

Function 53C2h - Get SWIFT Dynamic Device Data

This function returns the dynamic device data of the connected SWIFT device.

Input

AX = 53C2h

Output

AX = Dynamic Device Data Word

Format of Dynamic Device Data Word

Bit 0	External Power Connected (1 = yes)
Bit 1	External Power Level (1 = Too High, 0 = OK)
Bits 2 - 15	Reserved (0)

For CyberMan, if the External Power Level is too high the tactile motor will not be allowed to function in order to prevent possible damage to the motor.

4

Technical Notes

This section contains miscellaneous technical notes that don't fit into the preceding sections, as well as answers to common questions about programming and supporting the CyberMan controller.

Loading the driver HIGH

Logitech CyberWare drivers can in general be loaded HIGH under DOS 5.0 and later, but there is one complication.

CyberWare 6.31 needs a contiguous block of at least 44KB to load, even though it only occupies about 21KB of memory after loading. This is a fairly large UMB, so it is not uncommon to see the mouse driver failing to load high because there is not a large enough free block. Usually, the order of loading can be changed so that the mouse driver is loaded earlier, and this resolves the problem.

Protected Mode

The CyberWare 6.31 driver is a 'real mode' driver. If your program is executing in protected mode, you must ensure that any buffers passed into the driver are allocated entirely in DOS memory. This restriction applies to the following pointers in the SWIFT API:

- The status buffer passed to Function 5301h (SWIFT_Get3DStatus)
- The Event Handler Setup Data buffer passed to Function 53C0h (SWIFT_ExchangeEventHandler)
- The Event Data Structure, passed in the Event Handler Setup Data block
- The Static Device Data structure passed to Function 53C1h (SWIFT_GetStaticDeviceInfo)

Sample code is included in the CyberMan Programming Toolkit, showing programming techniques for use with the Watcom C/386 and MetaWare High C compilers, and the Rational Systems DOS/4G and DOS/4GW and PharLap 386|DOS DOS Extenders.

Using the Rational Systems DOS/4GW DOS Extender provided with Watcom C/386, it is not possible to use the function 53C0h Event Handler service - use the standard Mouse Function 12/Function 20 services.

Appendix A

Logitech Developer Support

Logitech aids its developers with an automated fax service, electronic bulletin board services, and developer support.

If you need support for your Logitech toolkit, we recommend that you read this appendix first, so you'll know how and where to get it.

The following sections describe the available Logitech developer support services.

Customer Service, Technical Support or Developer Relations?

This section tells you who to contact for appropriate support.

Customer Service. Logitech Customer Service provides *non-technical* product support, such as product pricing, product replacement, upgrade and update information, product warranty, and order status.

Technical Support. Logitech Technical Support provides *technical* product support, such as software or hardware questions.

Developer Support. Logitech Developer Relations provides developer support, such as toolkit questions or how to register as a developer.

Sending a Fax to Logitech Developer Relations

The fax number for Logitech Developer Relations is

(510) 713-5038

Please address all communication to: Attn. Developer Relations.

Internet E-mail to Logitech Developer Relations

The Internet address for Logitech Developer Relations is

developer_support@logitech.com

Logitech FaxBack Service

FaxBack™ is a toll-free, automated fax response service. Using your touch-tone telephone and fax machine, you can request many types of documents: most commonly-asked questions, available toolkits, technical notes, and developer services. FaxBack sends the documents to your fax machine in minutes.

First, call FaxBack and order the Logitech Developer FaxBack catalog that lists the latest available developer support documents. For the catalog, request document number 4700. To reach FaxBack, call:

(800) 245-0000 (in the US)

Support Phone Numbers and Addresses Worldwide

This section includes support addresses and telephone numbers. The Logitech Developer Support phone line connects you to an automated attendant, which is monitored throughout the day in order to provide timely response from Logitech.

You can also write for support. Address your letter to the appropriate Logitech address and to the attention of Developer Relations and your toolkit (i.e. Attn: Developer Relations, CyberMan Programmer's Toolkit). Please include your daytime phone number and the best time to reach you.

U.S.A. and Canada
Product Support: (510) 795-8100
Developer Support: (510) 713-5DEV
Logitech Inc.
Attn: Developer Relations
6505 Kaiser Drive
Fremont, CA 94555

Switzerland, Europe, Africa, & Middle East
Product Support and Developer Support
(Switzerland): ++41 (0) 21-869-98-51
For the rest of Europe: ++41 (0) 21-869-98-55
Logitech SA
CH-1122 ROMANEL/MORGES

Logitech Far East Ltd.
Product and Developer Support: ++886 (0) 2 746-6601
No. 2 Creation Road 4, Science - Based Industrial Park
Hsinchi Taiwan R.O.C.

Logitech On-Line

If you have a modem, you can communicate with Logitech on the following electronic bulletin boards.

LBBS (Logitech Bulletin Board Service)
With a 300, 1200 or 2400 baud modem, call LBBS 24 hours a day, 7 days a week. Set the communication parameters on your modem to either: 7 bits, 1 stop bit, and even parity; or 8 bits, 1 stop bit, and no parity.

In the United States, call: (510) 795-0408
In Europe, call: ++41 (0) 21-869-98-17

CompuServe
If you are a member of CompuServe Information Service, you can get the latest Logitech Product Support information.

From the CompuServe system prompt, type:

GO LOGITECH

CyberMan™ 3D Controller

LOGITECH

The most advanced way to master 3D games

For IBM Compatibles

CyberMan is a revolutionary input device that's built specifically for hard-core gamers. It allows you to move quickly and freely in 3D space, instead of enduring the limitations of 2 dimensional motion.

CyberMan makes you the master of space with a comfortable shape and high precision that quickly puts you where you want to be.

The new pulsating tactile feedback feature even lets you *feel* 3D. Now you'll feel the impact of your enemy's weapons as they bounce off your armor. Nothing else makes your 3D games so real.

Extra directional control enhances the game by giving you more freedom to move through the environment. It provides true proportional control in X and Y, and discrete control for Z, pitch, yaw and roll. Because CyberMan provides full 3D motion and includes support for virtual reality games and applications, it's an investment in high-quality entertainment that you won't outgrow.

A whole new way to play games

With all-in-one control, CyberMan significantly reduces the number of times you'll stop in the middle of 3D adventure to give a keyboard command. Absolute mapping to your screen and high resolution give you more motion and more precision with less movement. CyberMan is easy to use, and it's designed to be comfortable, no matter how many passages you navigate, galaxies you conquer, or villains you destroy.

CyberMan gives you full 3D motion

Feel the action with pulsating tactile feedback CyberMan is the first entertainment device that lets you feel the action as well as see and hear it. When you turn on the pulsating tactile feedback, you'll get a reaction from as simple a thing as bumping into a wall. This exclusive CyberMan feature makes the latest games more realistic because you'll feel everything that happens to your character. Depending on the game, you'll know when you've run into a locked door in a blind tunnel, feel bruised as the Amazon you're wrestling throws you to the ground, and feel the full impact of taking a shot in the back.

Works with the games you play

CyberMan works with all the games you play with a mouse – now and in the future. To get the full benefit of CyberMan's 3D motion and pulsating feedback, use it with games that fully support it. CyberMan is compatible with ordinary mice, ensuring compatibility with existing games that rely on conventional 2D mouse control. And, it also provides all the 3D control you'll need for the virtual reality games and applications that lie in your future.

Take advantage of full 3D motion The three-button head of CyberMan sits on a post set into the base. To change X and Y motion, slide the post from side to side or forward and backward. For up and down motion, simply pull up or push down on the CyberMan head. Pivot the head forward or backward to change pitch. Twist the head left or right to manipulate yaw. Tilt the head from side to side for roll. CyberMan makes it easy to get the power and freedom of true 3D control.

Compatibility Guaranteed CyberMan is guaranteed to be compatible with all Logitech and Microsoft mice.

Includes extra value 3D games Try out the latest in 3D games. The CyberMan package includes fast action interactive games so you can immediately experience the excitement of 3D motion and tactile feedback.

Built with Logitech quality

CyberMan is built to last. It is rugged and durable to endure the rigors of high speed, hard driving games. CyberMan comes with a limited lifetime warranty and is backed by Logitech's product support hotline 7 days a week. Logitech is the world's pointing device leader, combining value and quality with advanced technology.

Specifications
Height: 3.5in (89mm)
Length: 7.5in (190mm)
Width: 6.75in (171mm)
Cable length: 6 ft (1.8m)
Connector: 9-pin serial (9- to 25-pin adaptor included)

System Requirements
IBM PC or compatible system with 386 processor or higher
PC or MS-DOS 3.3 or higher
CyberMan works without batteries, but the pulsating tactile feedback feature requires 2 AA batteries or an AC adaptor (not included).

Product Support
Call Logitech 7 days a week for technical support, or use our 24-hour electronic bulletin board. Take advantage of the FaxBack line to receive product information by return fax. There is also a Logitech Forum on CompuServe.

Product Support Hotline:	(510) 795-8100
Electronic Bulletin Board:	(510) 795-0408
FaxBack Line:	(800) 245-0000

Satisfaction Guaranteed
Logitech wants you to be perfectly happy with your CyberMan. If you are not completely satisfied with your investment, return CyberMan to your reseller within 60 days with the complete contents of the package and proof of purchase for a full refund. (Full details inside the package.)

Sales Information and Support
Call us for the dealer nearest you or product information during normal business hours.
In the U.S. and Canada: (800) 231-7717

LOGITECH
The Senseware™ Company

Logitech Inc.
6505 Kaiser Dr.
Fremont CA 94555
(510) 795-8500

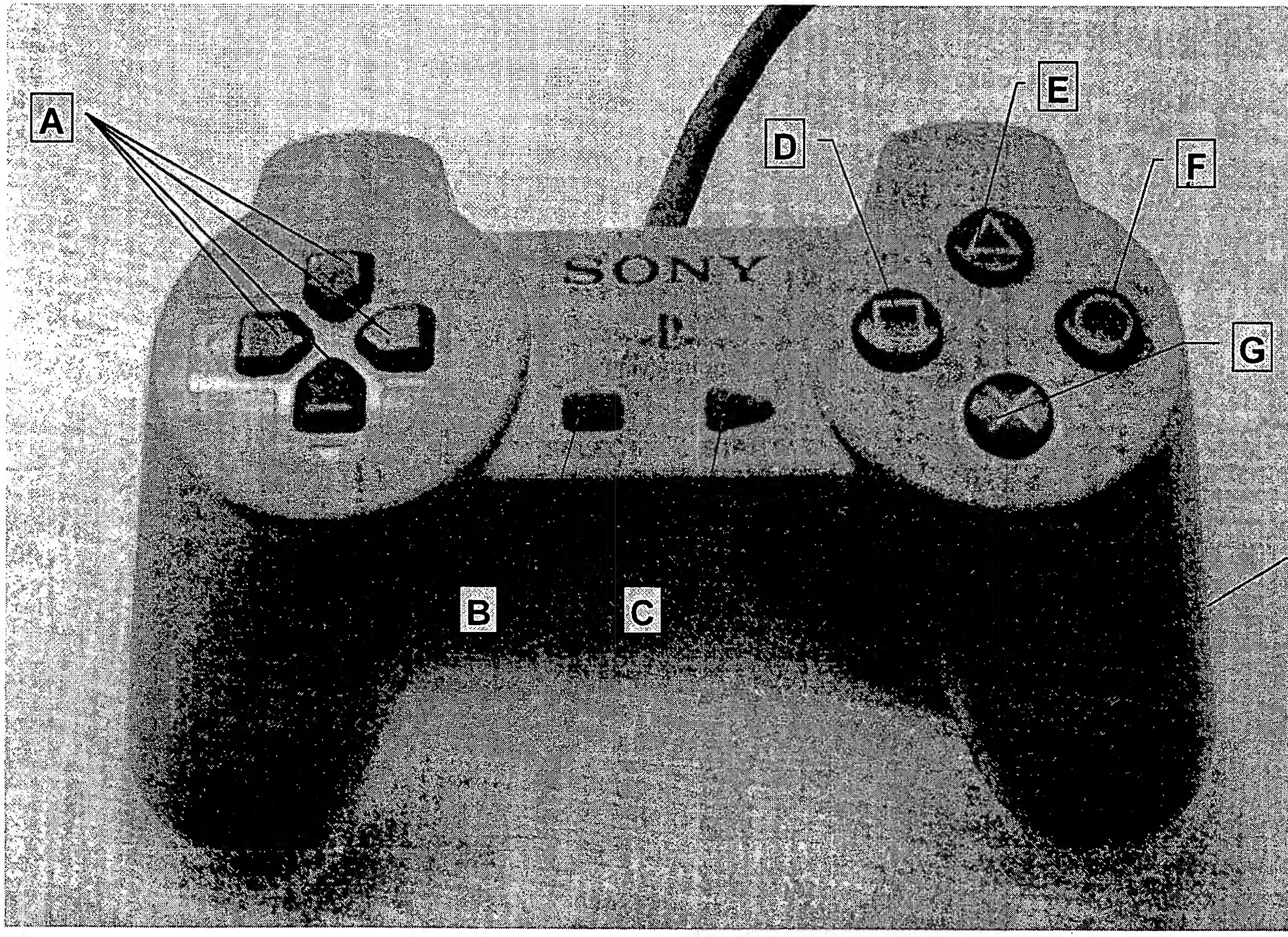
LOGITECH

Remy Zimmermann
SW Engineer

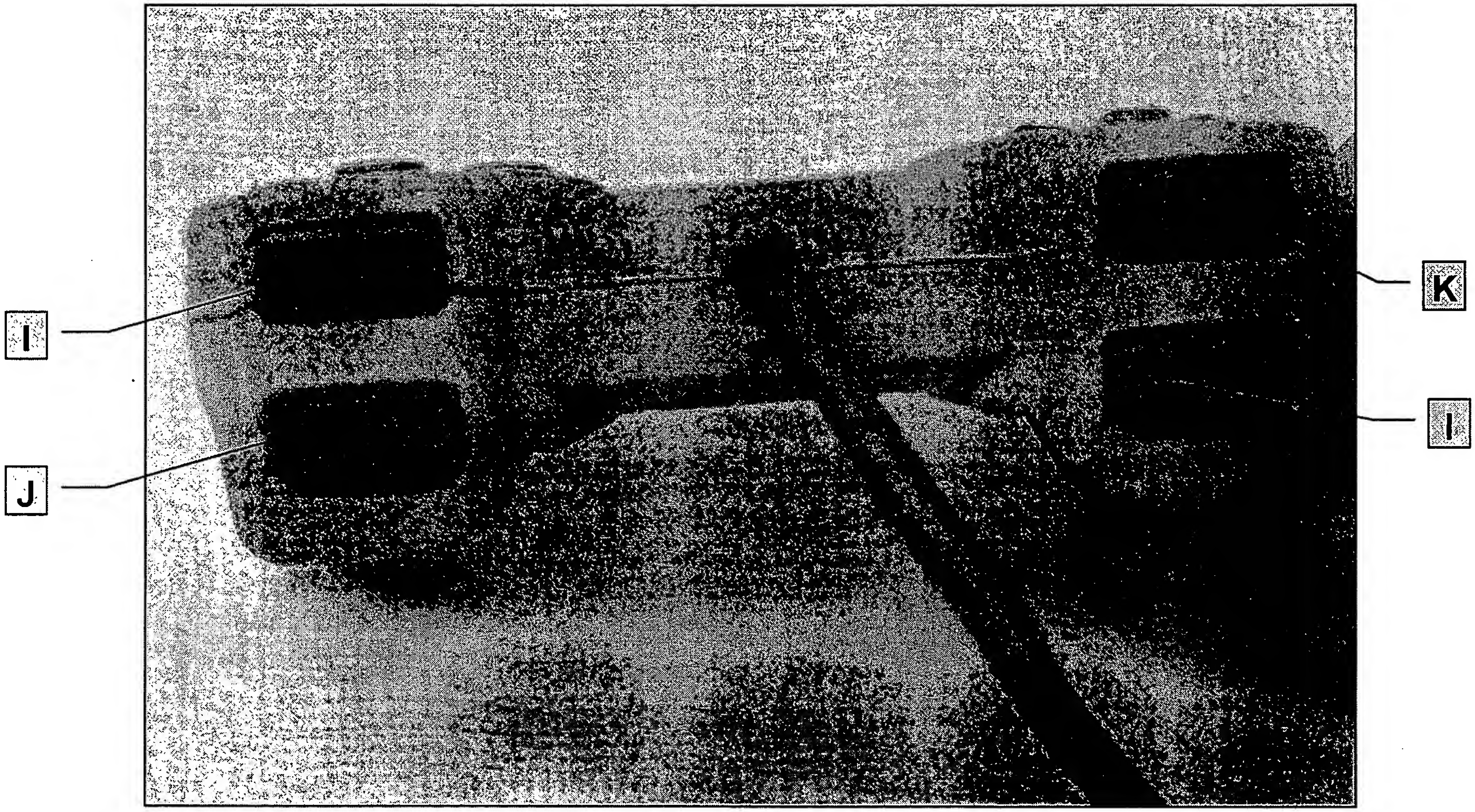
Logitech Inc.
6505 Kaiser Drive
Fremont, CA 94555
Main: (510) 795-8500
Direct: (510) 713-4449
Fax: ~~(510) 792-8901~~
510 - 713 - 5090

Space mouse
3D mouse

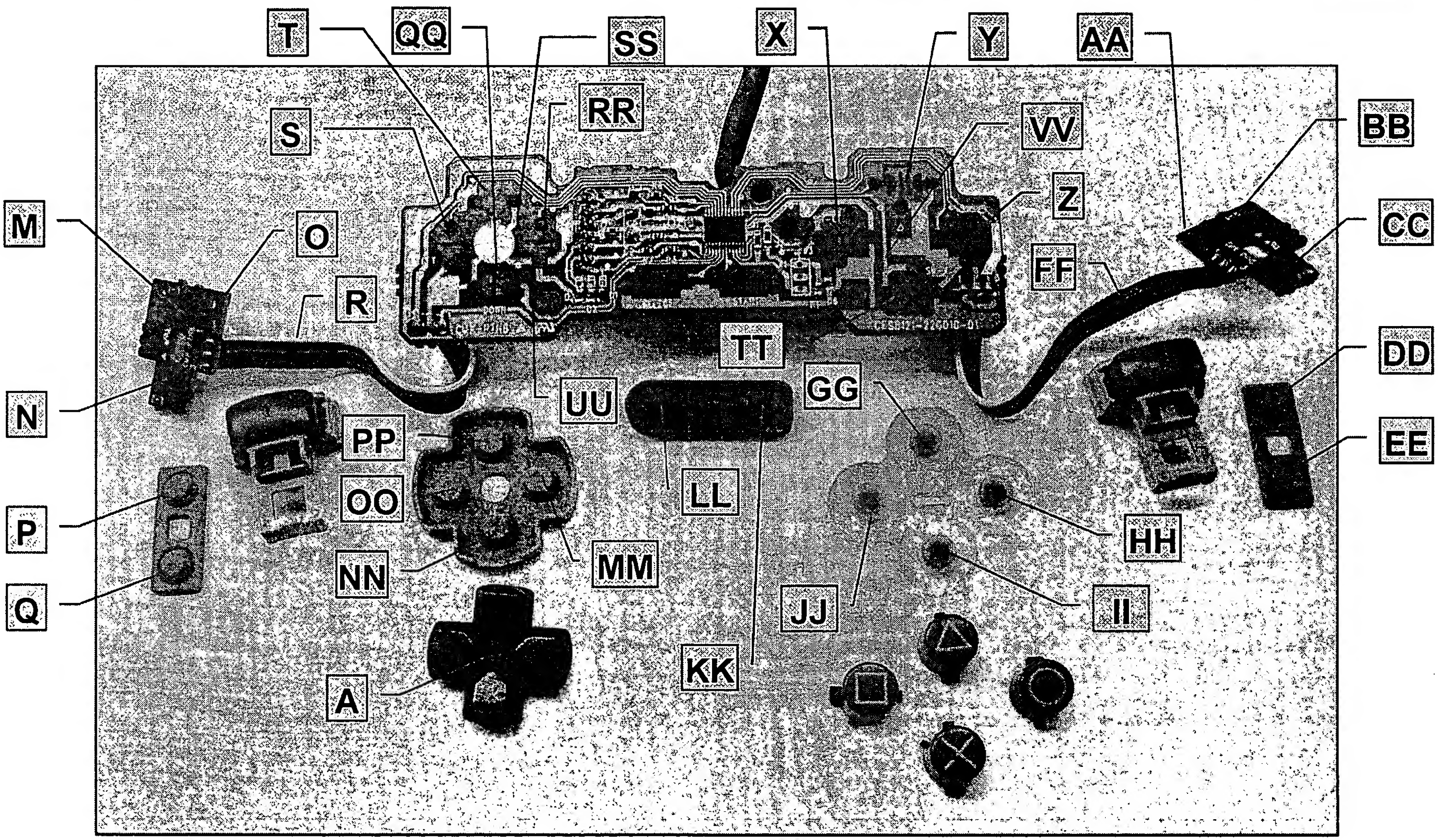
Sony Playstation Controller



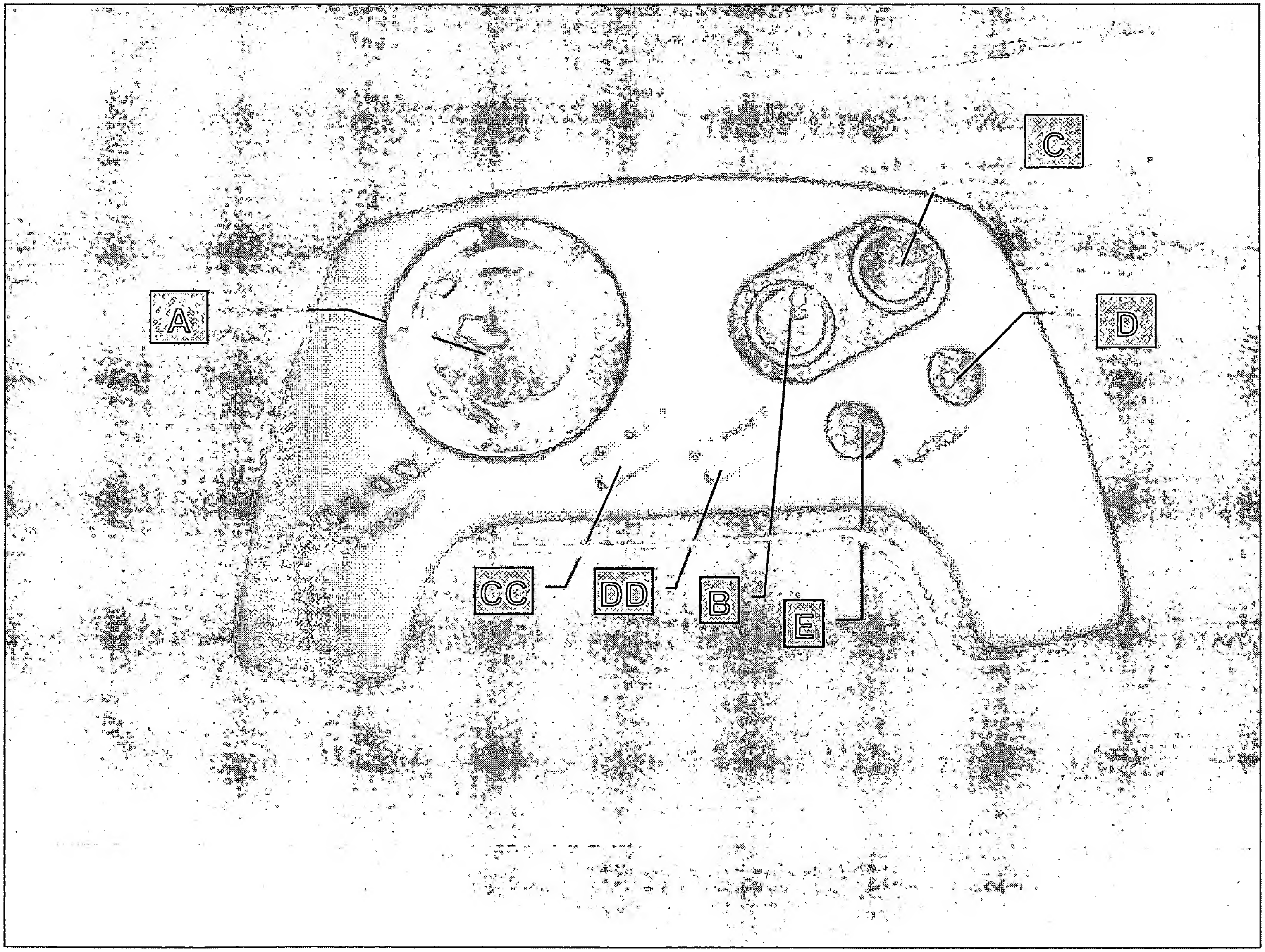
Sony Playstation Controller



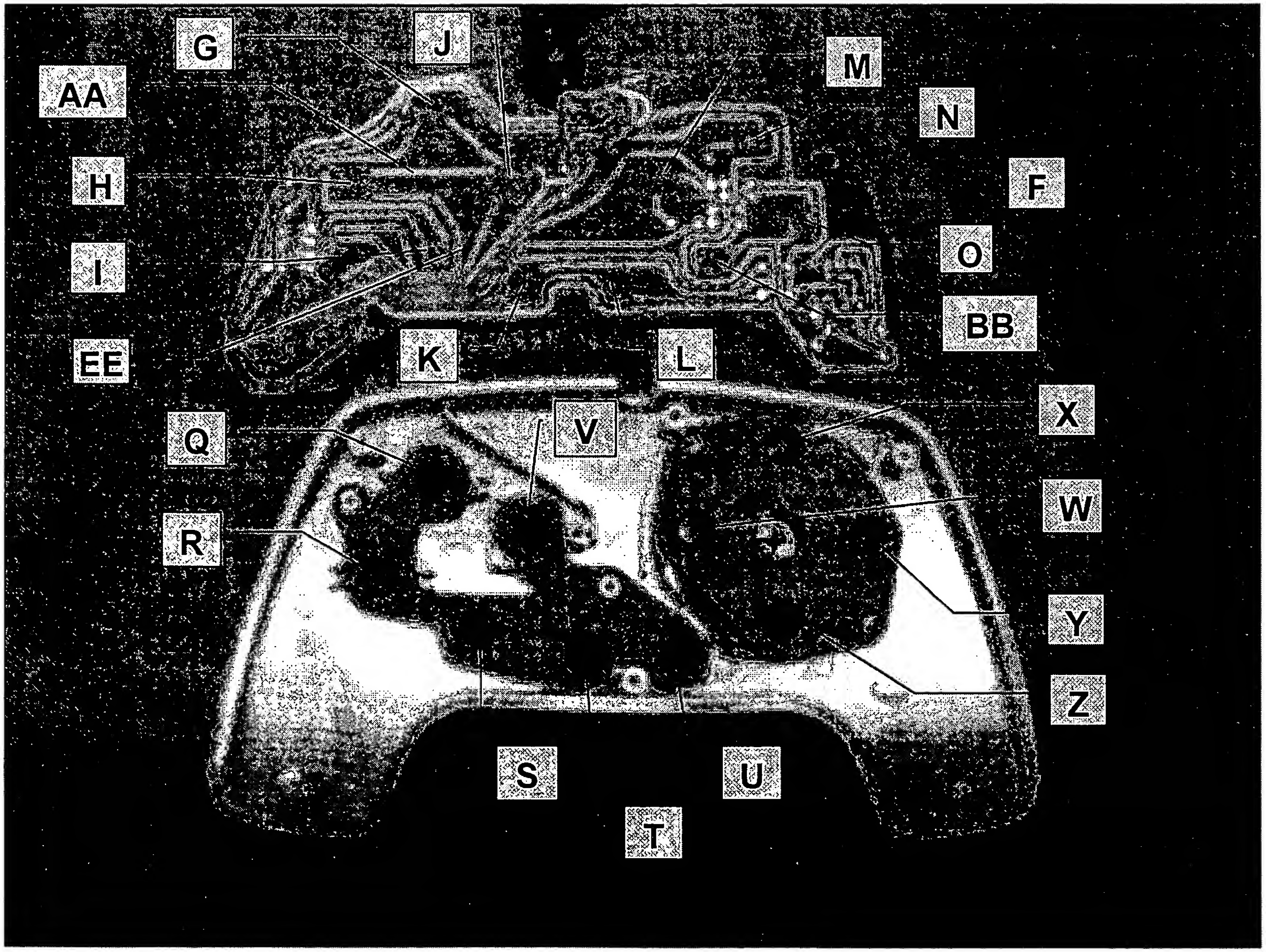
Sony Playstation Controller



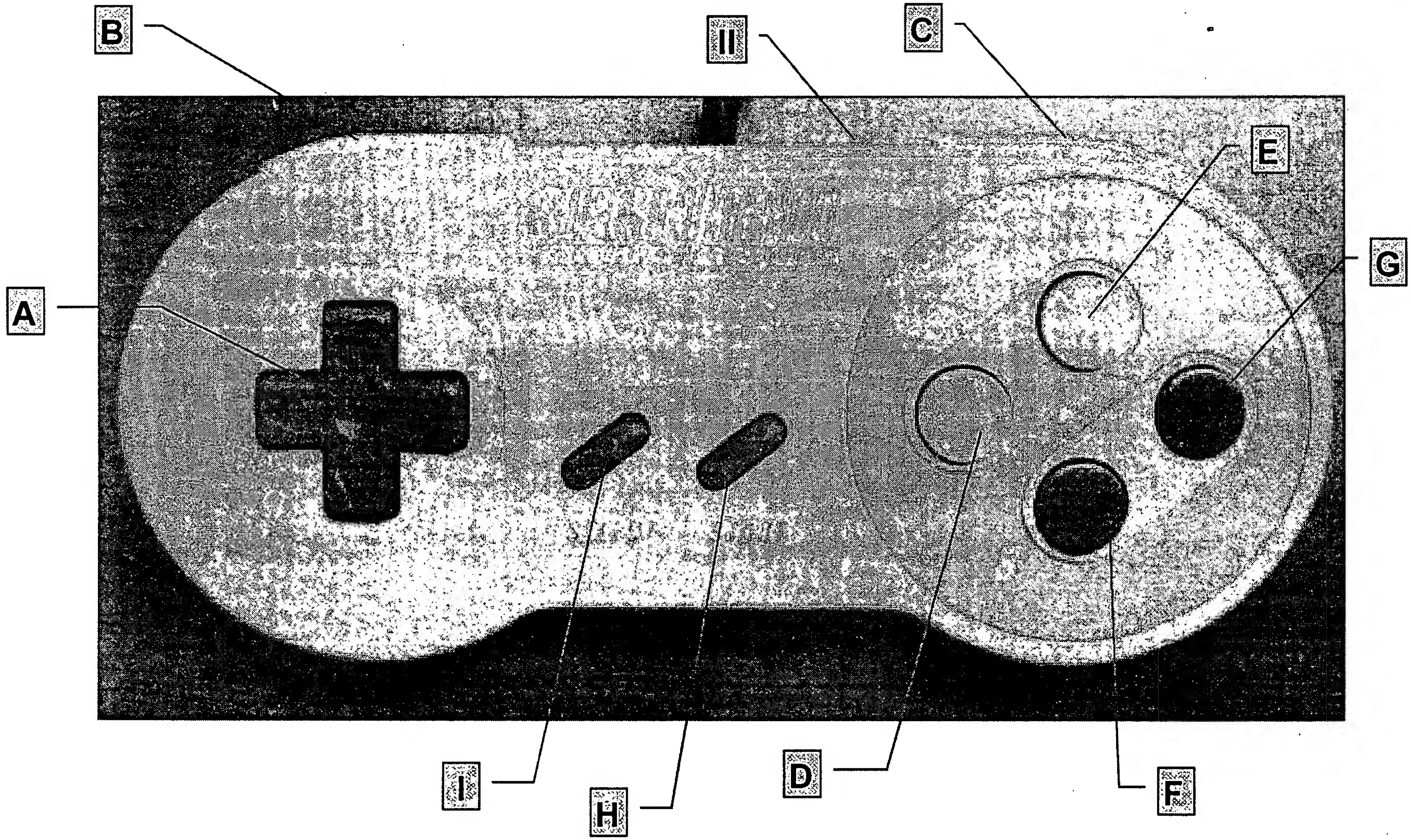
NES Max Controller



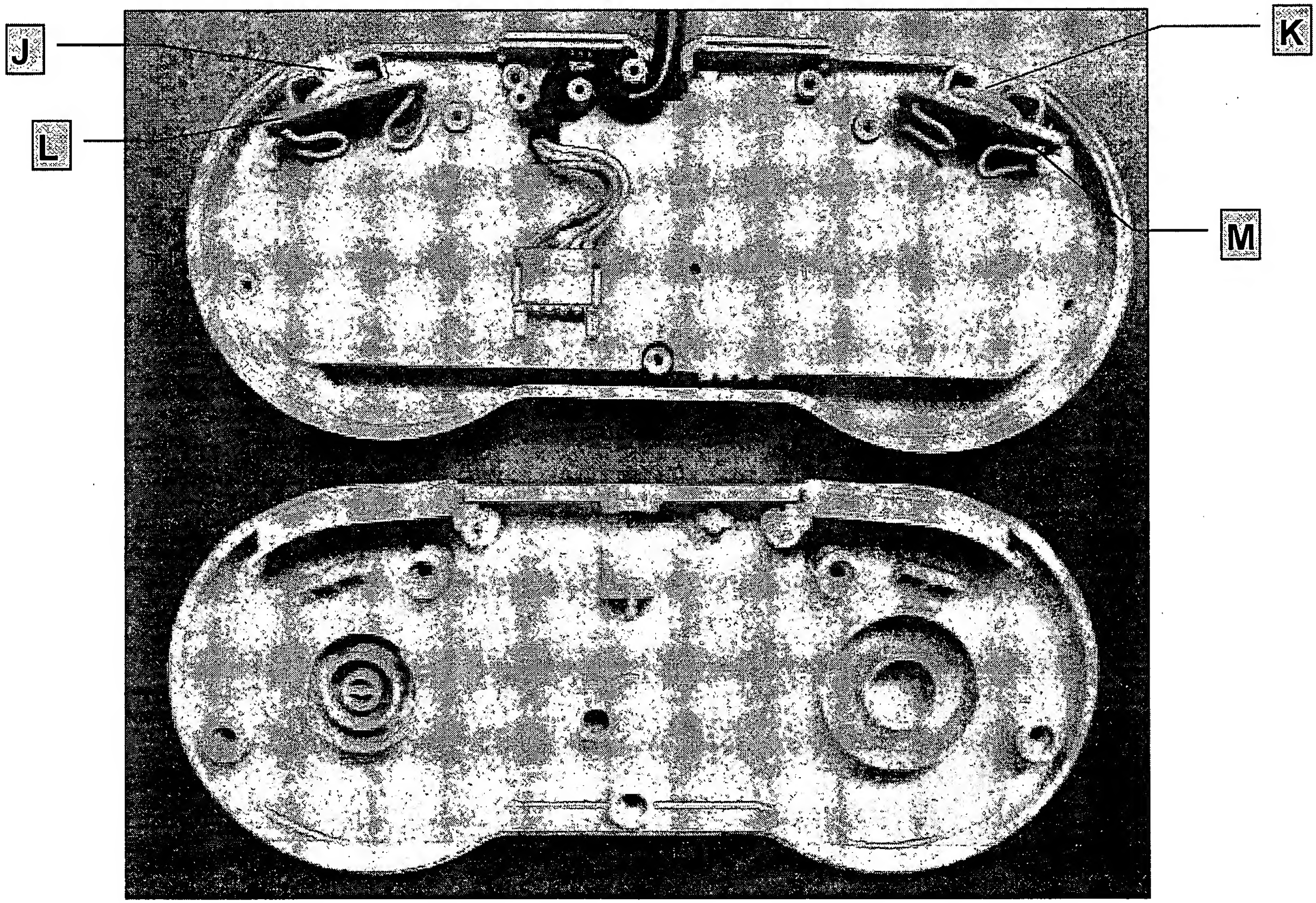
NES Max Controller



Super Nintendo Controller



Super Nintendo Controller



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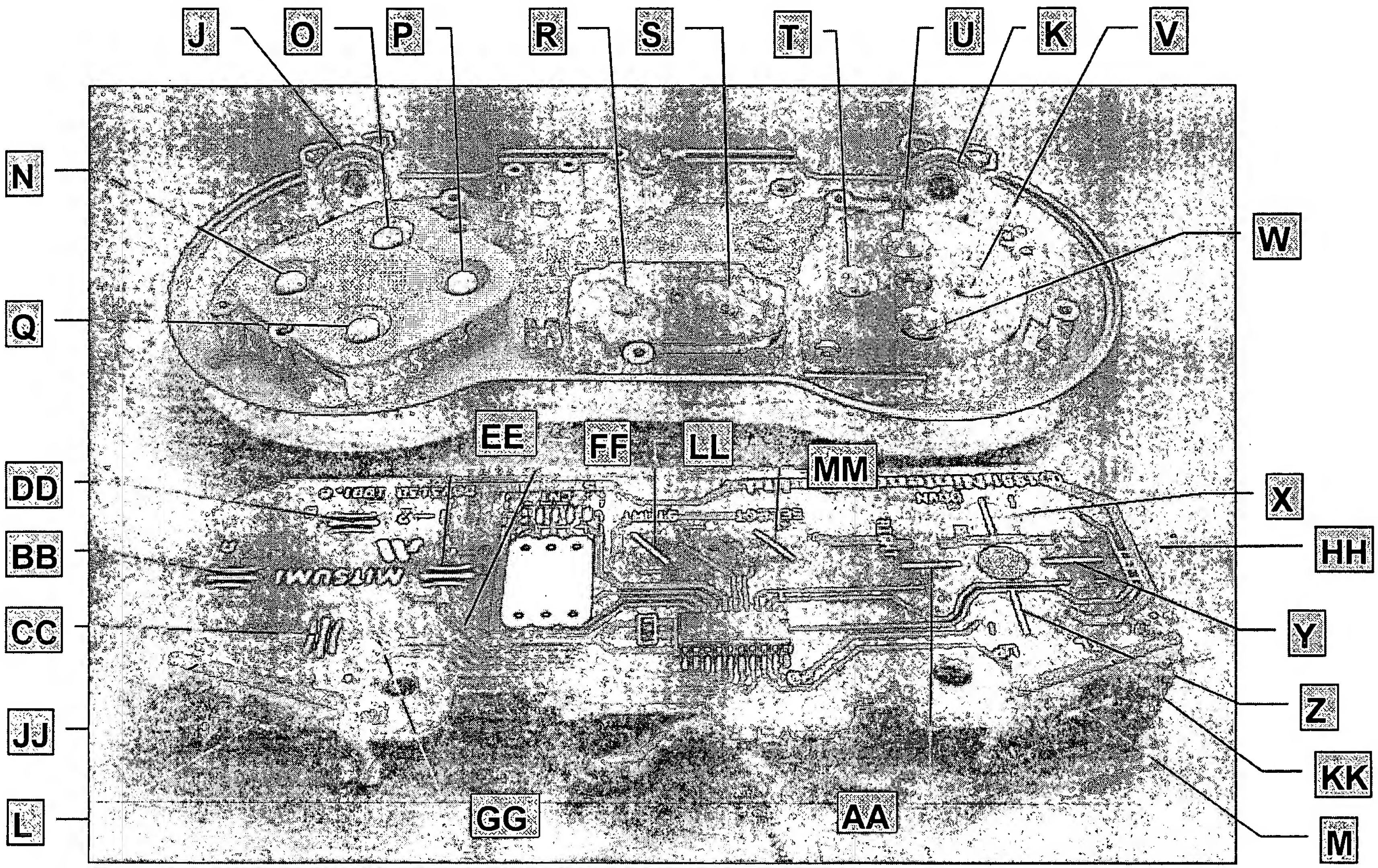
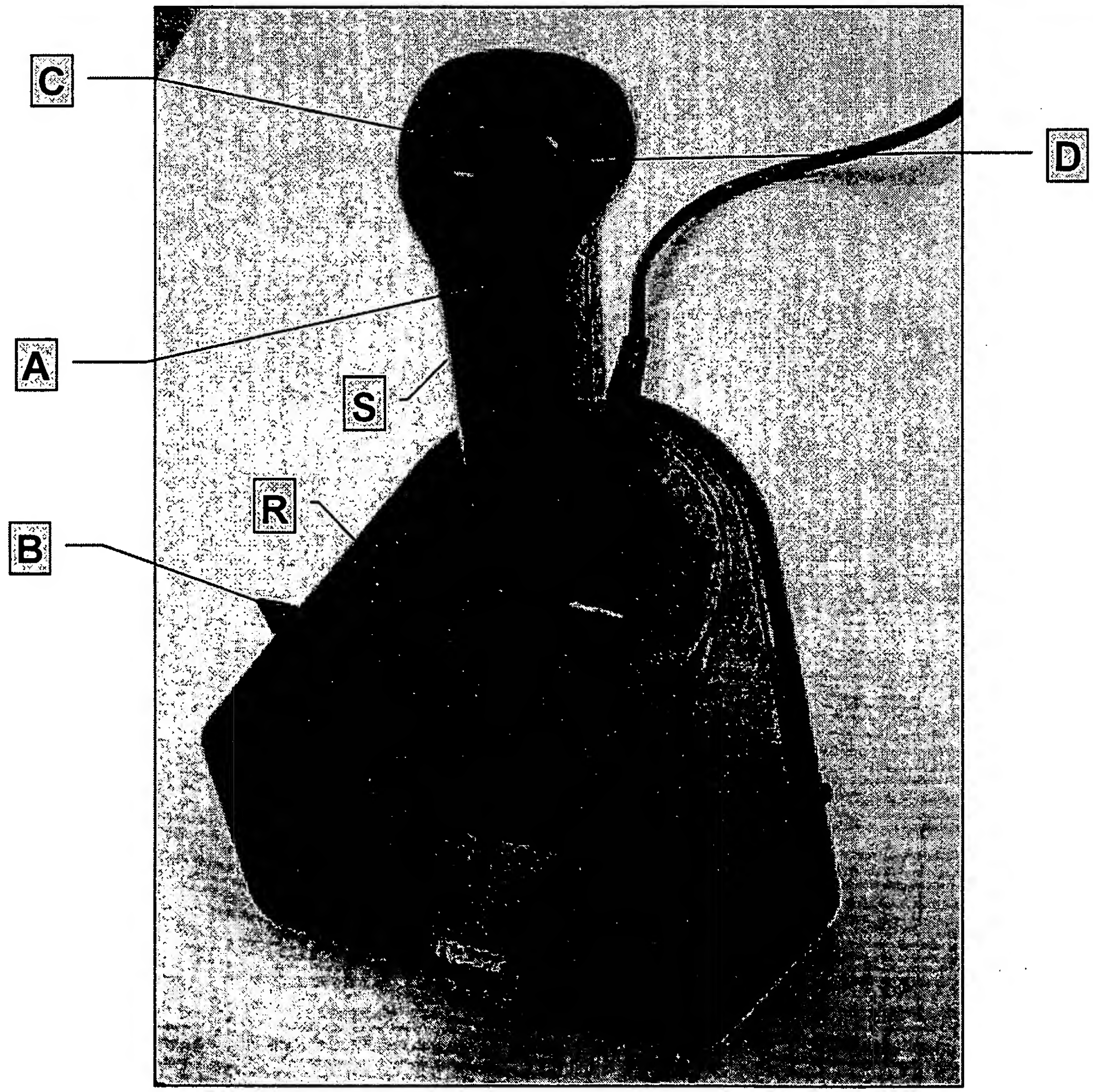


Kraft Thunderstick Joystick



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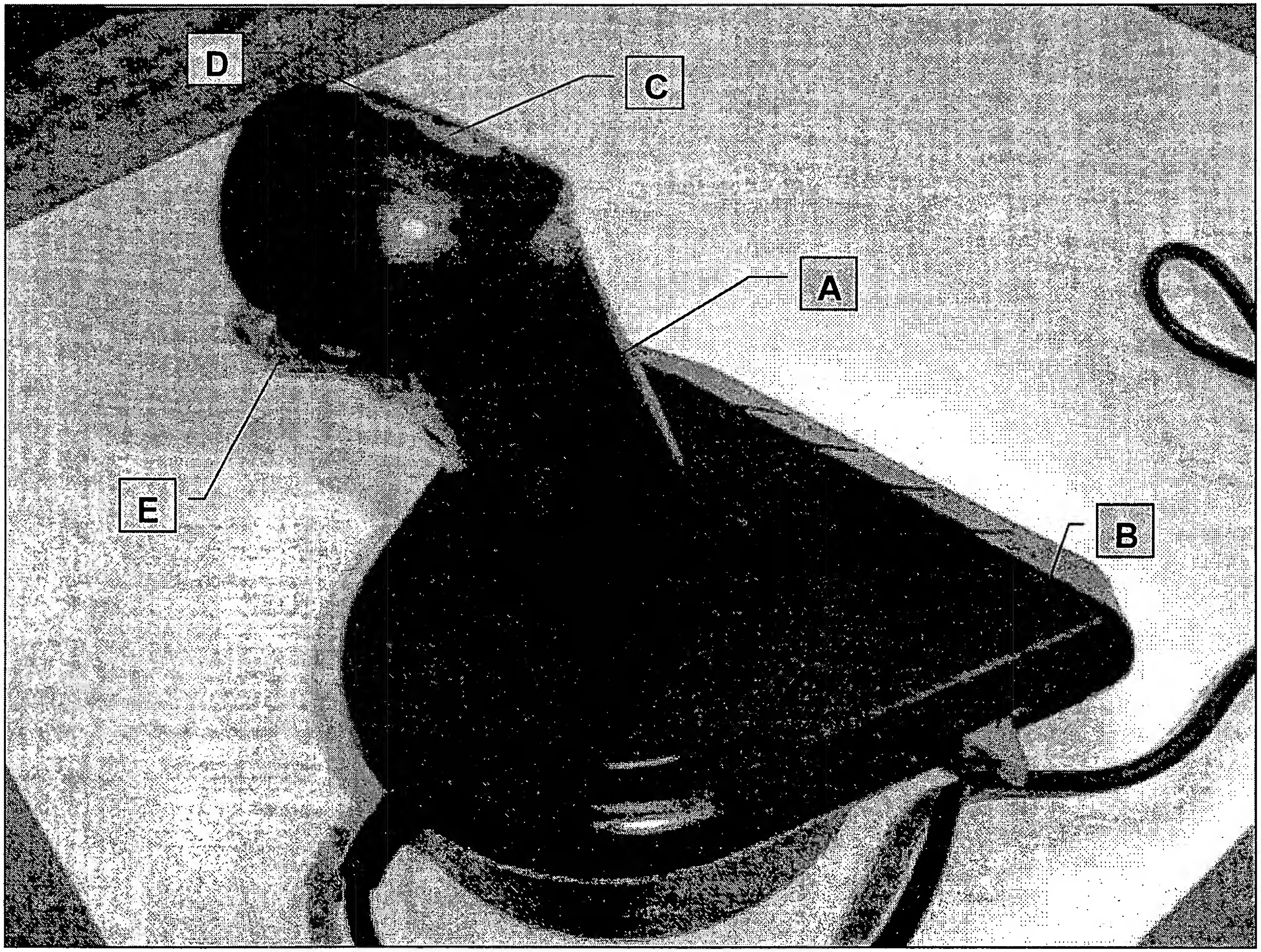

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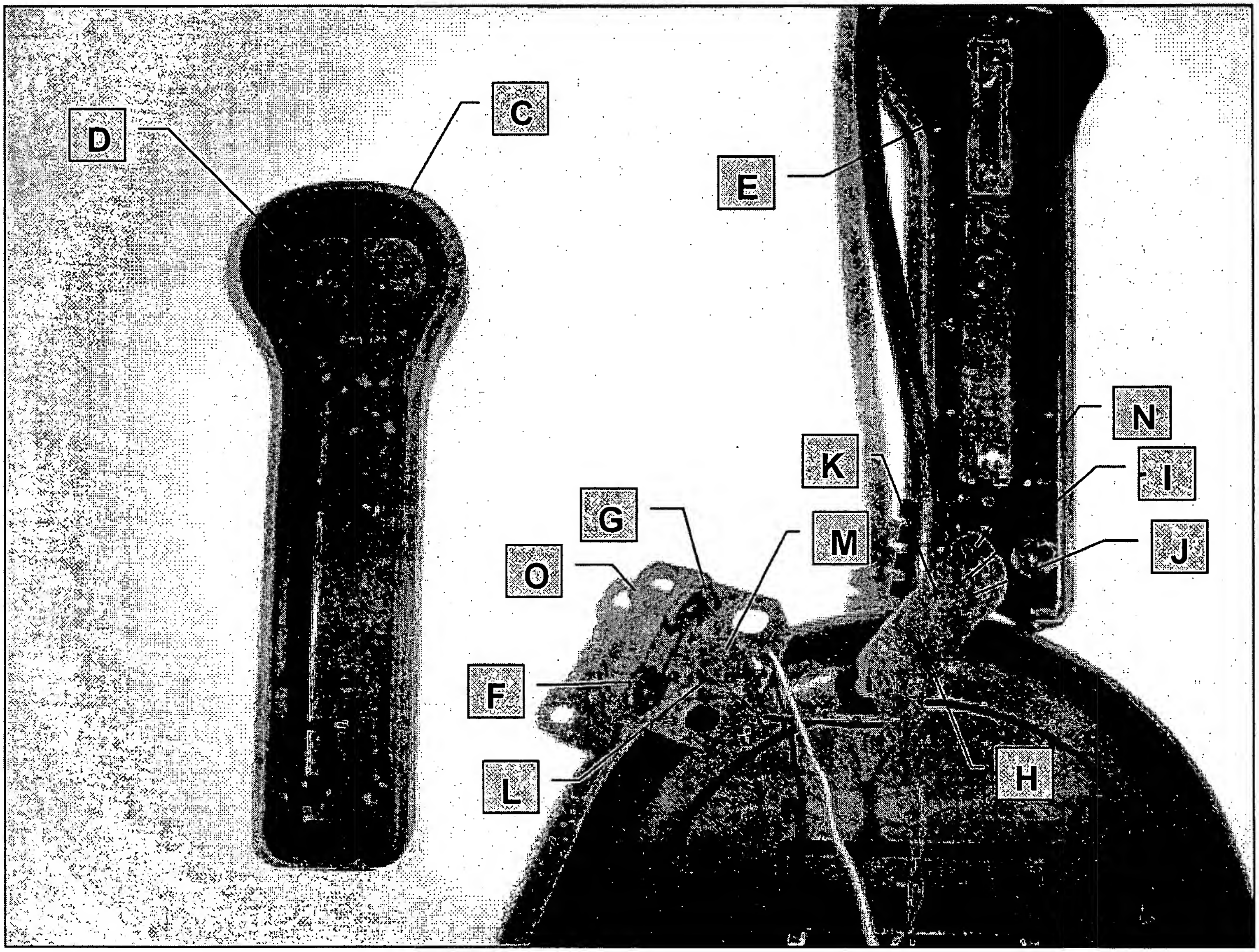
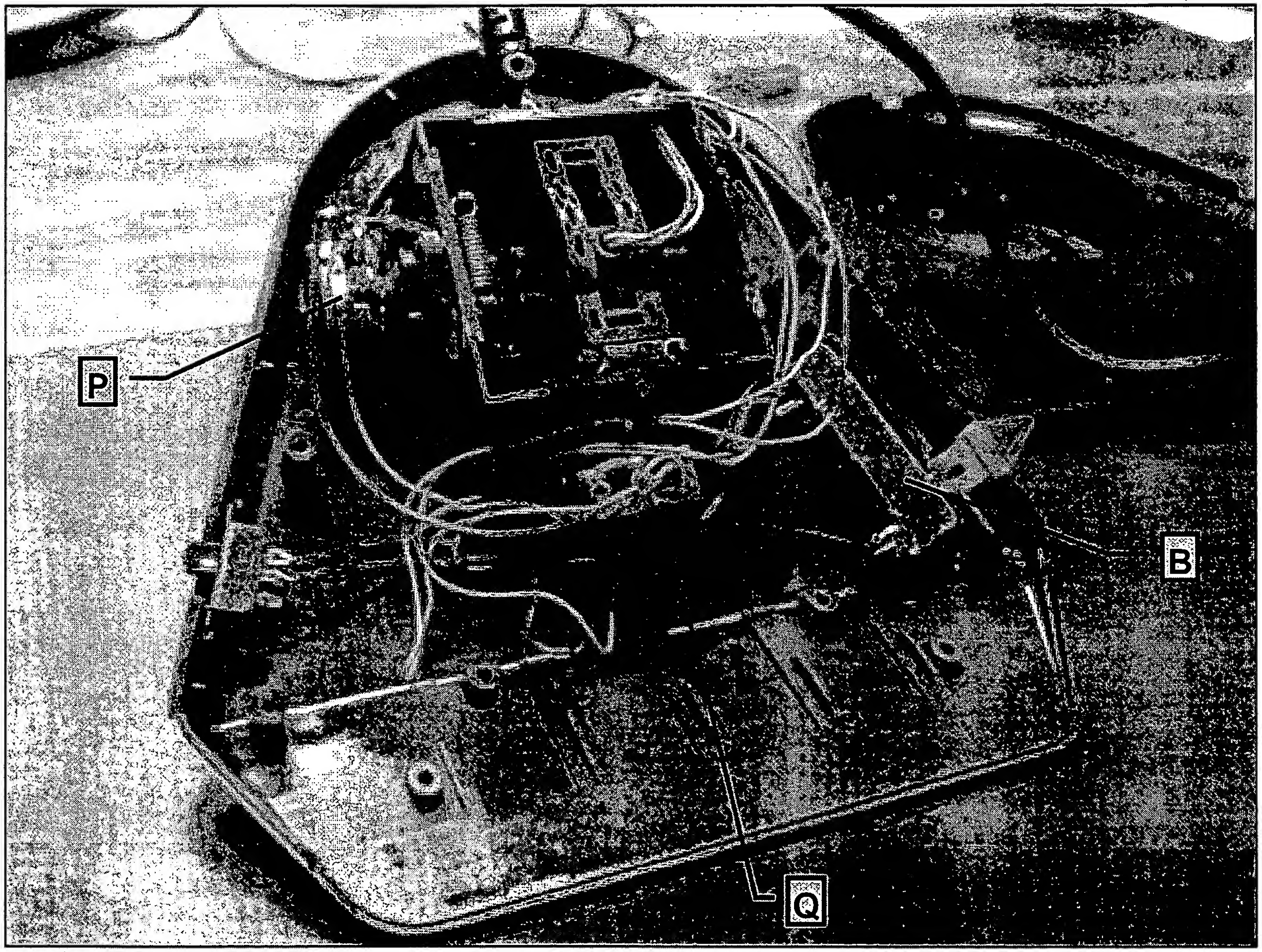
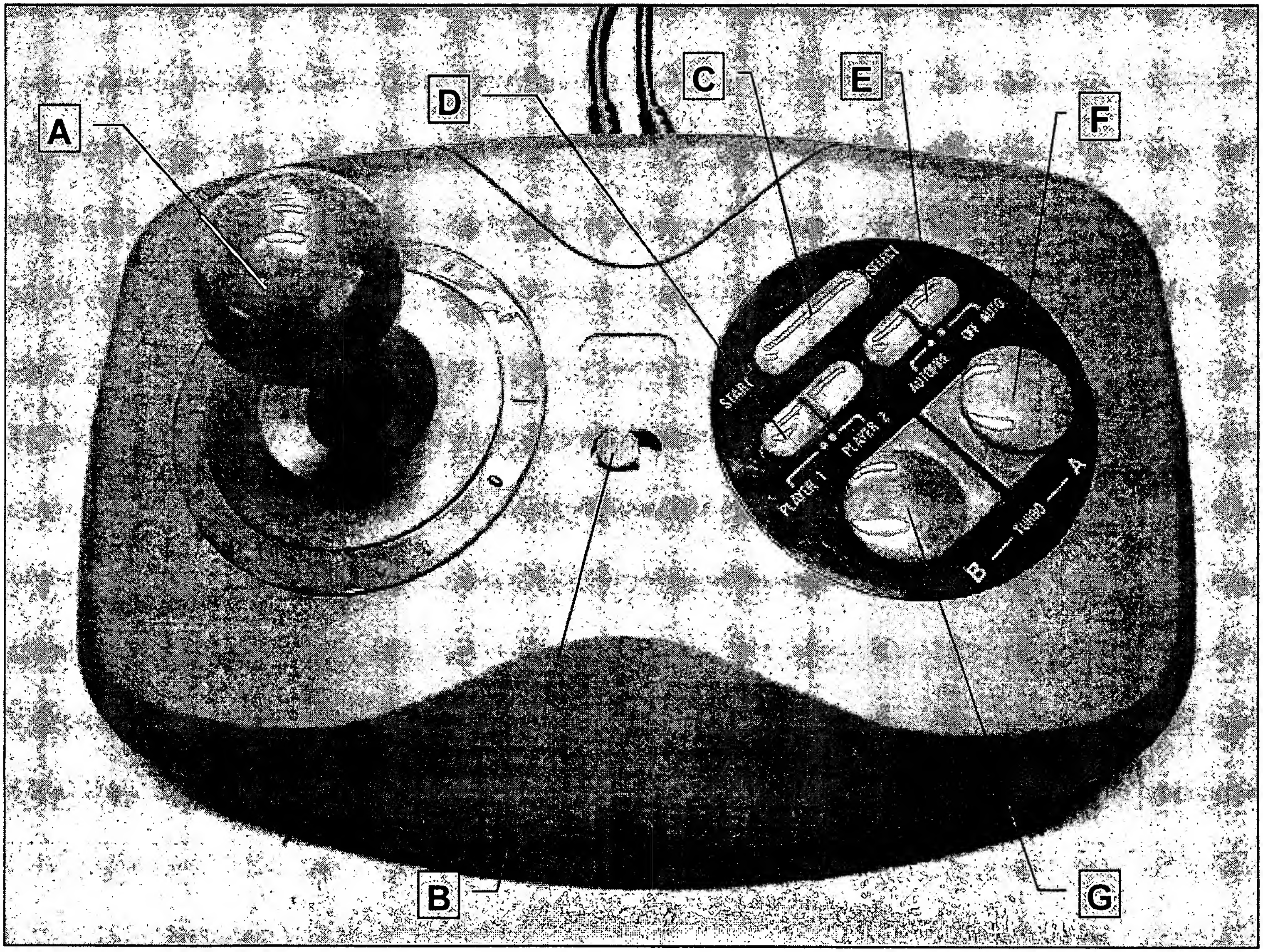


Kraft Thunderstick Joystick



Quickshot QS-128n Controller



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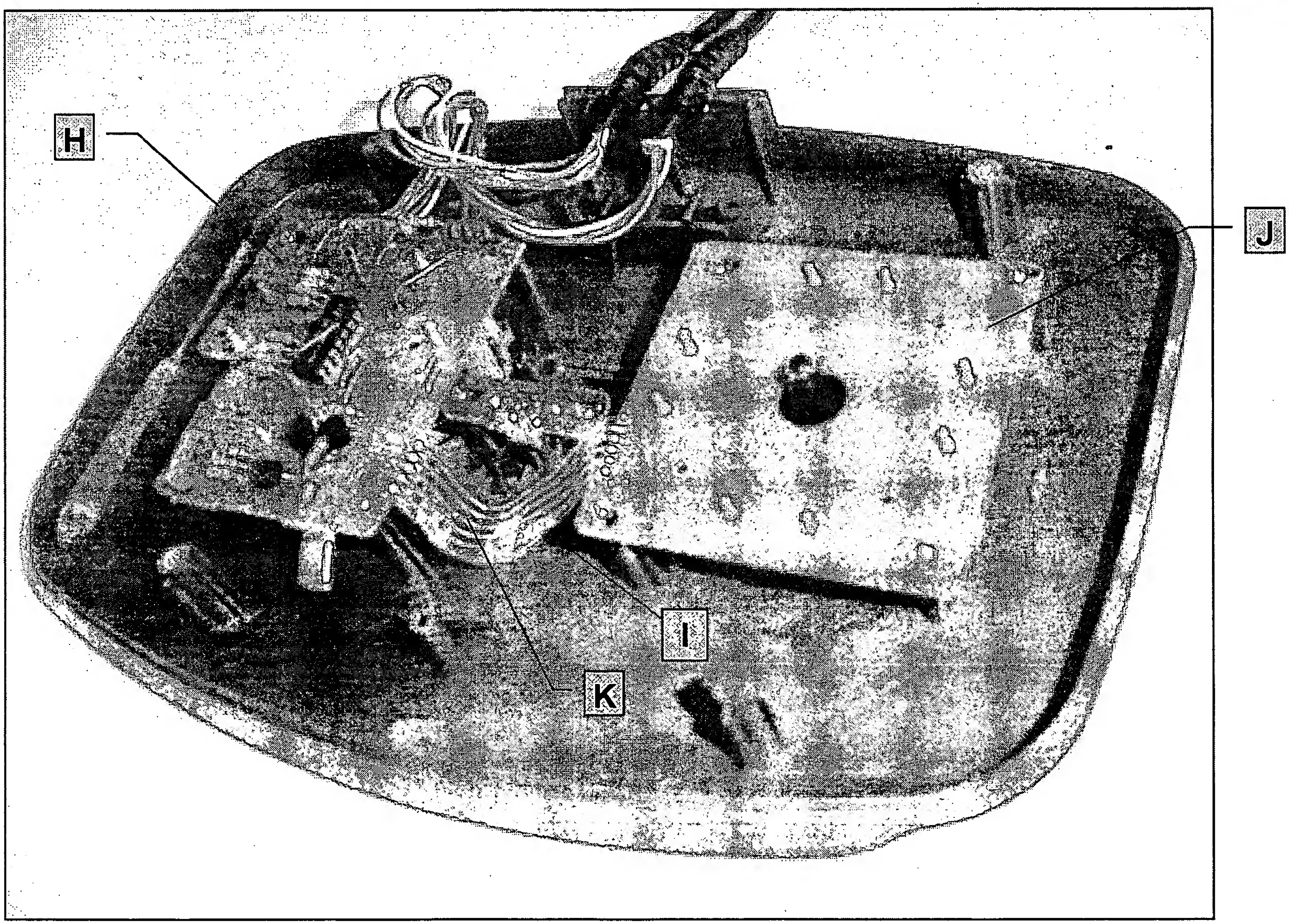

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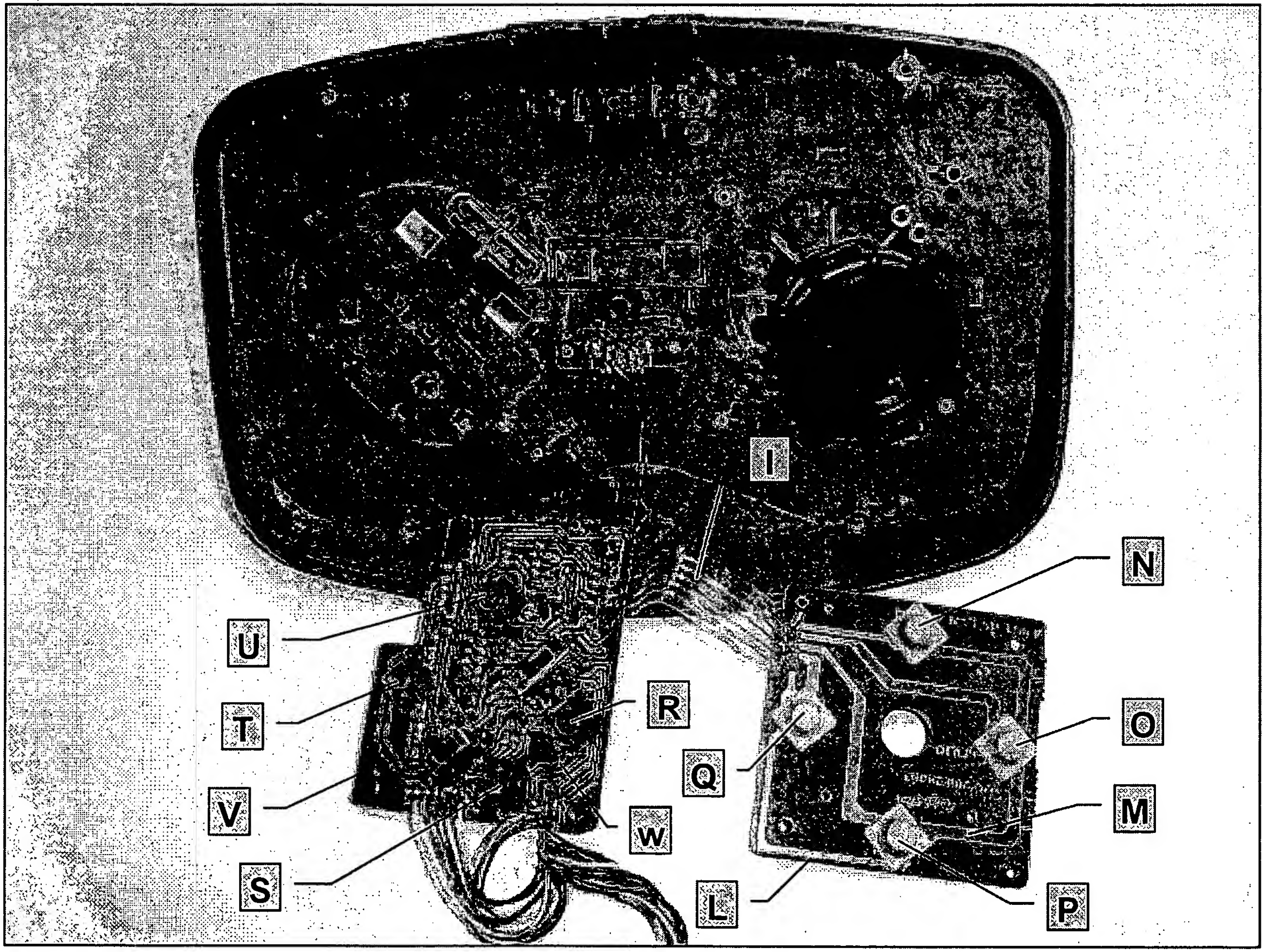

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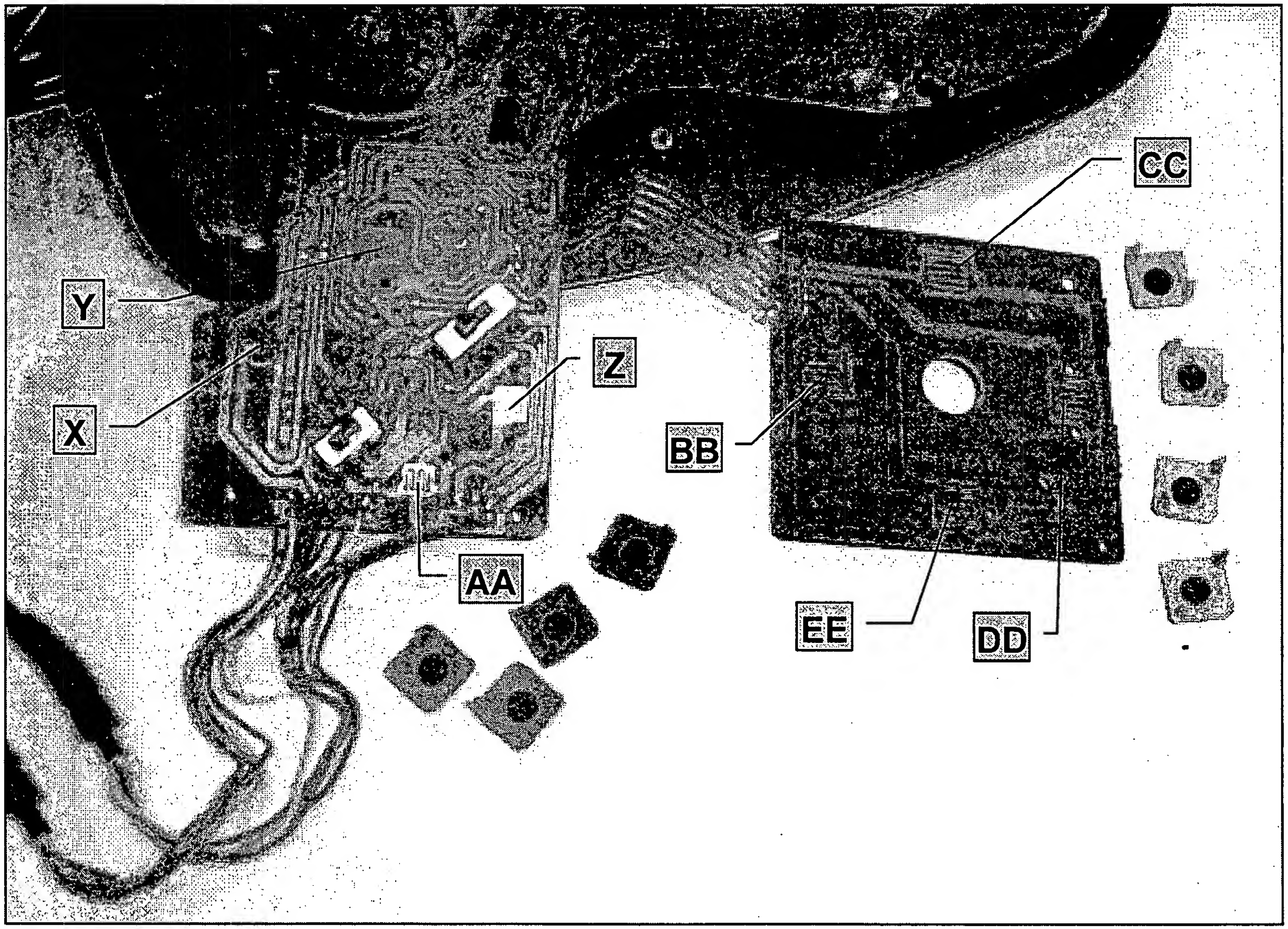

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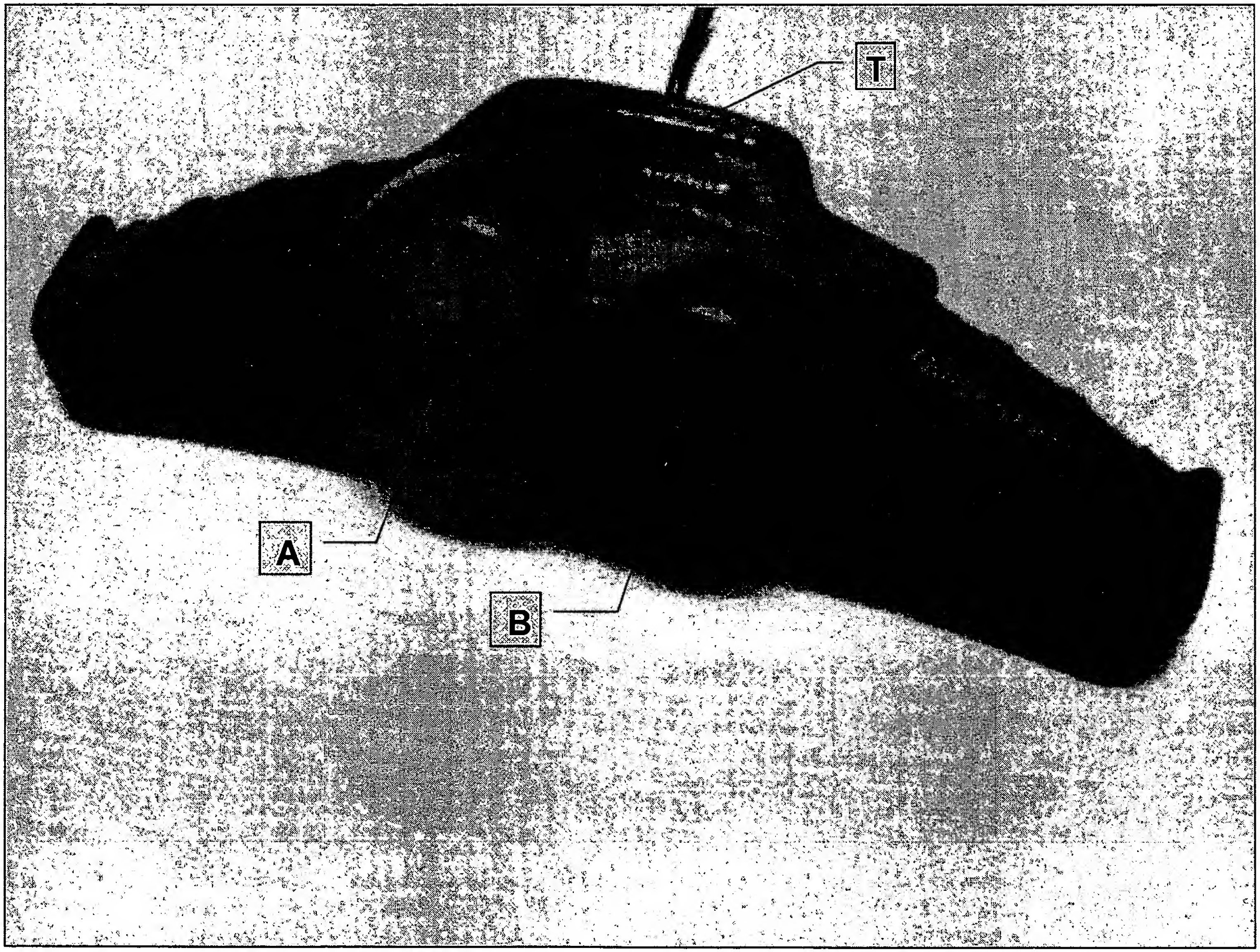

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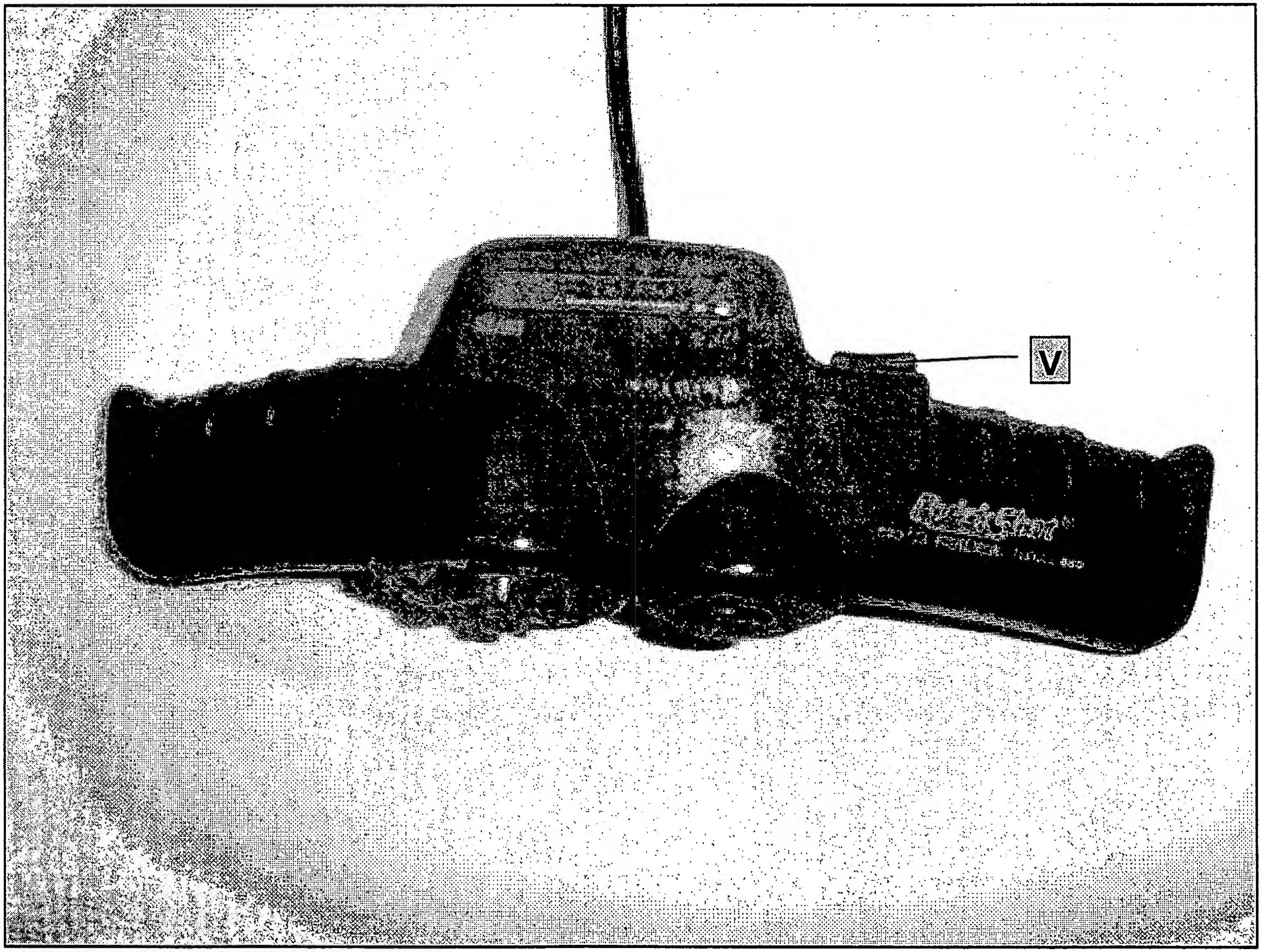

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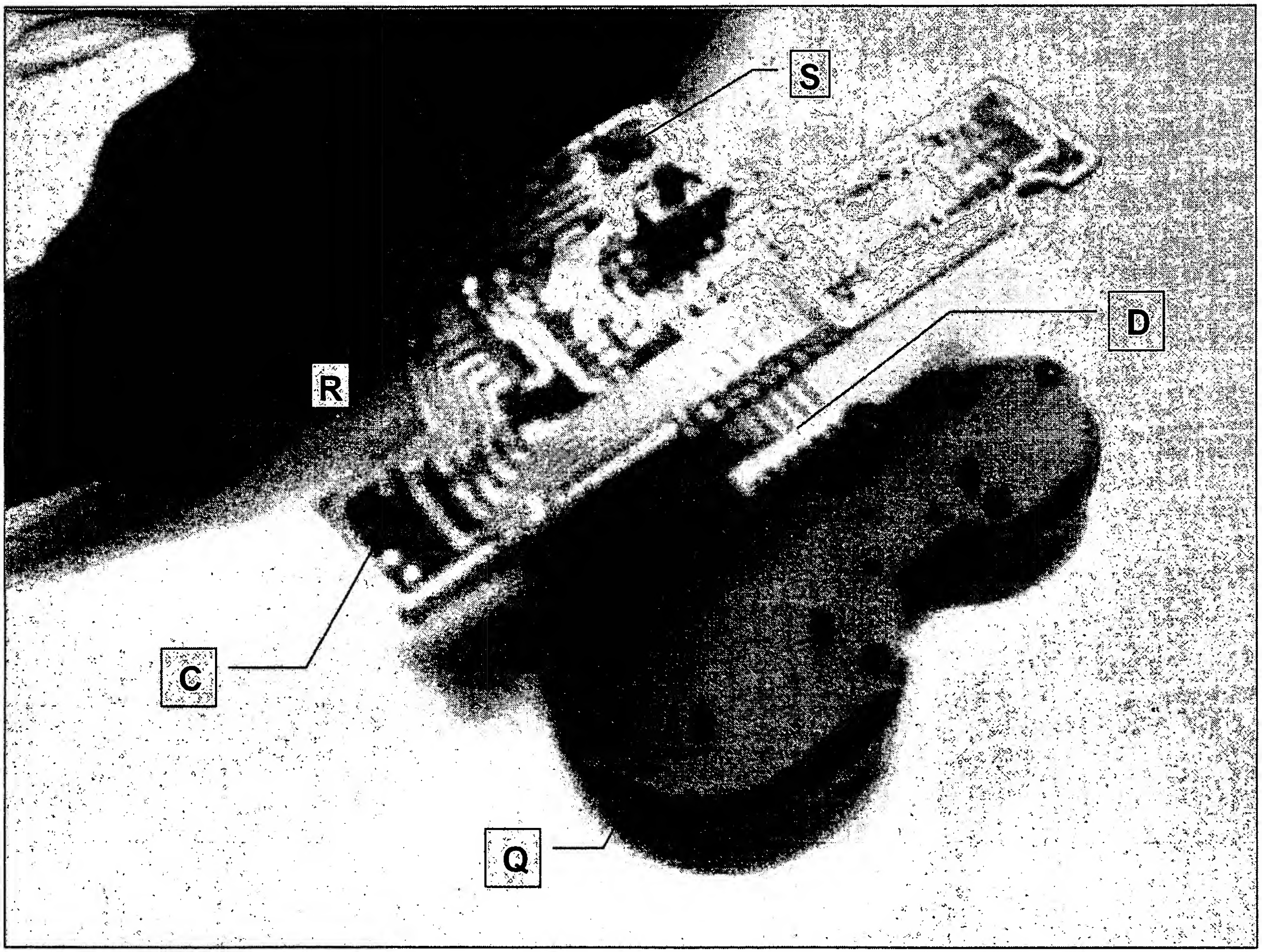

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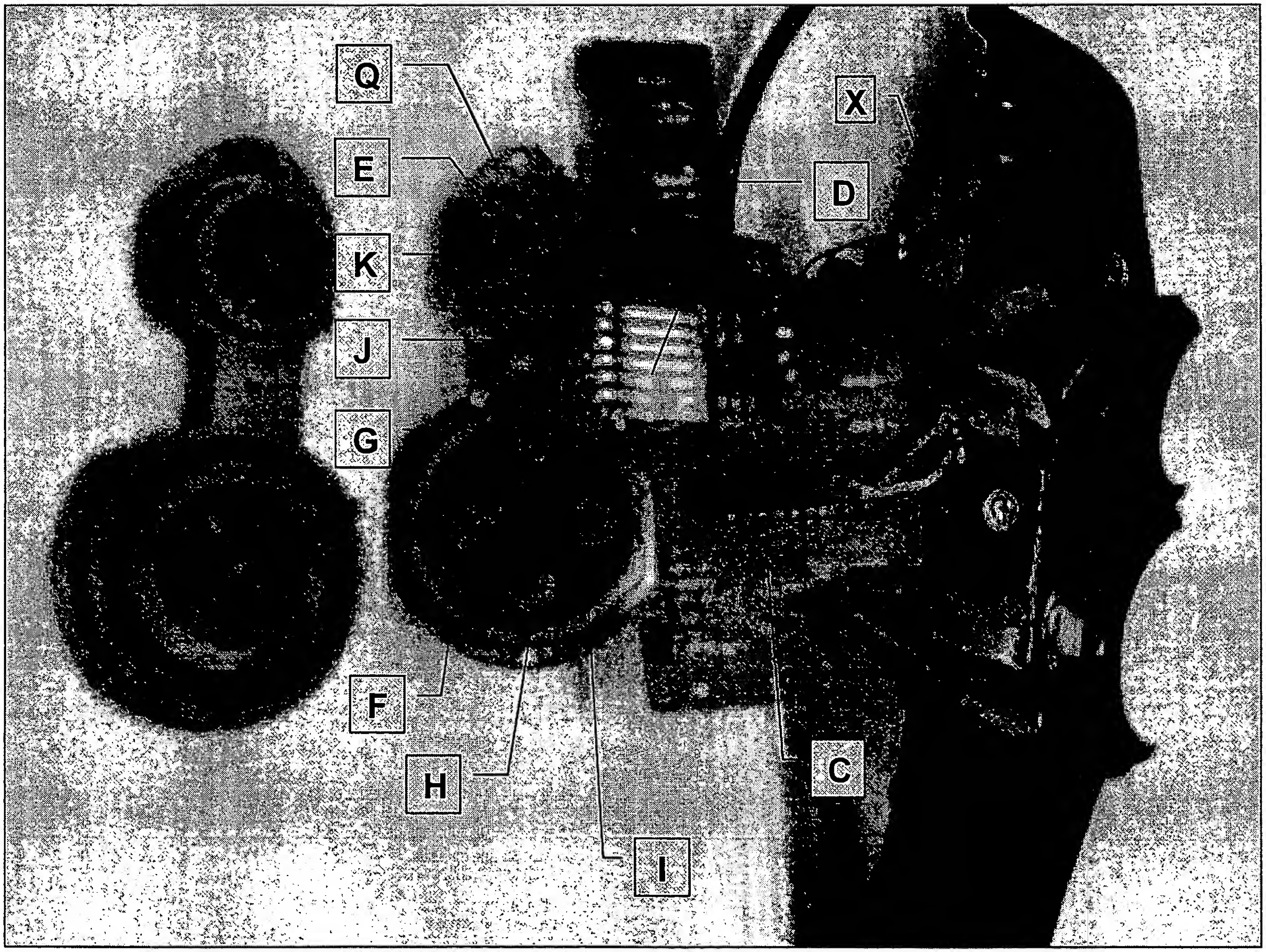

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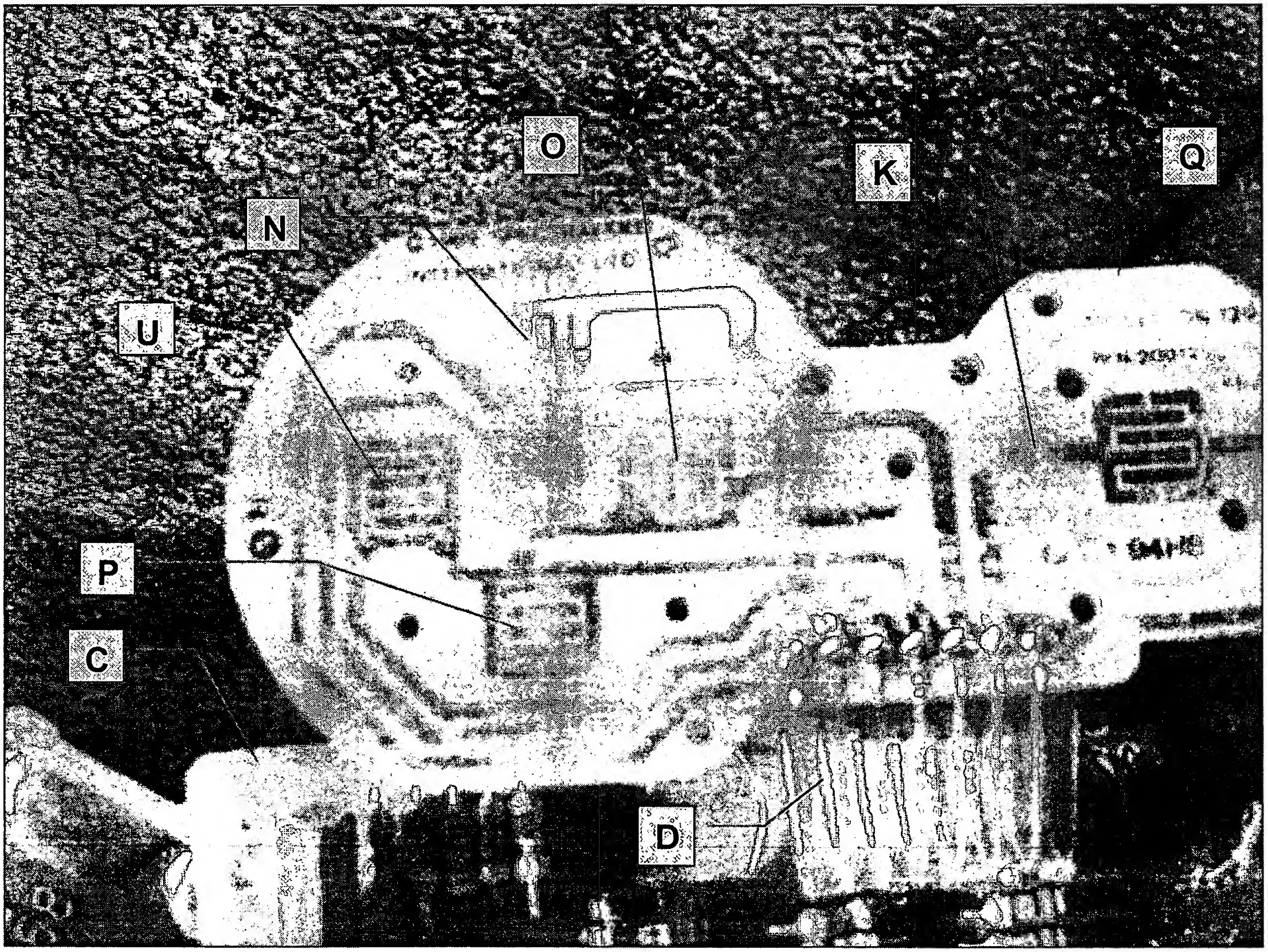

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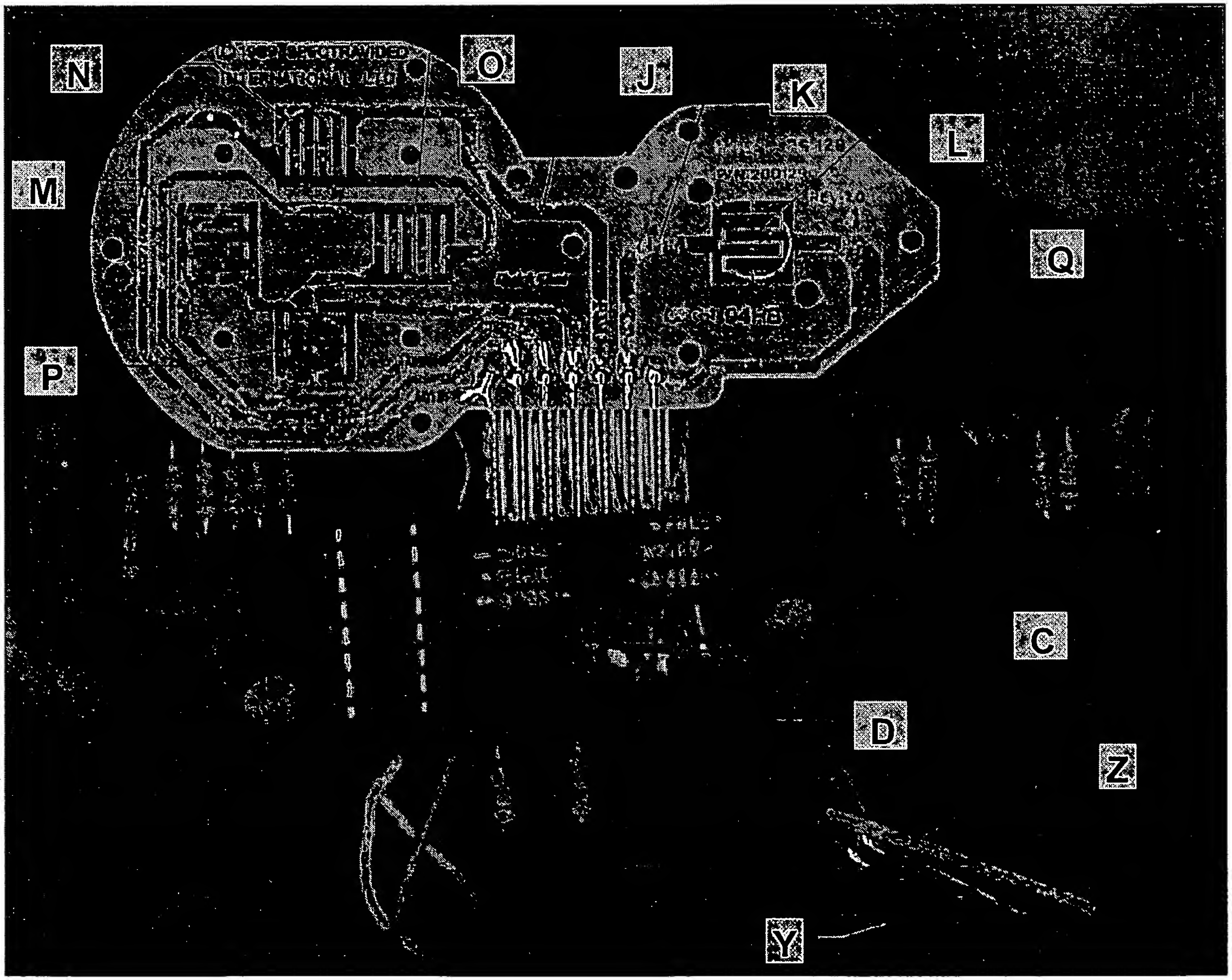

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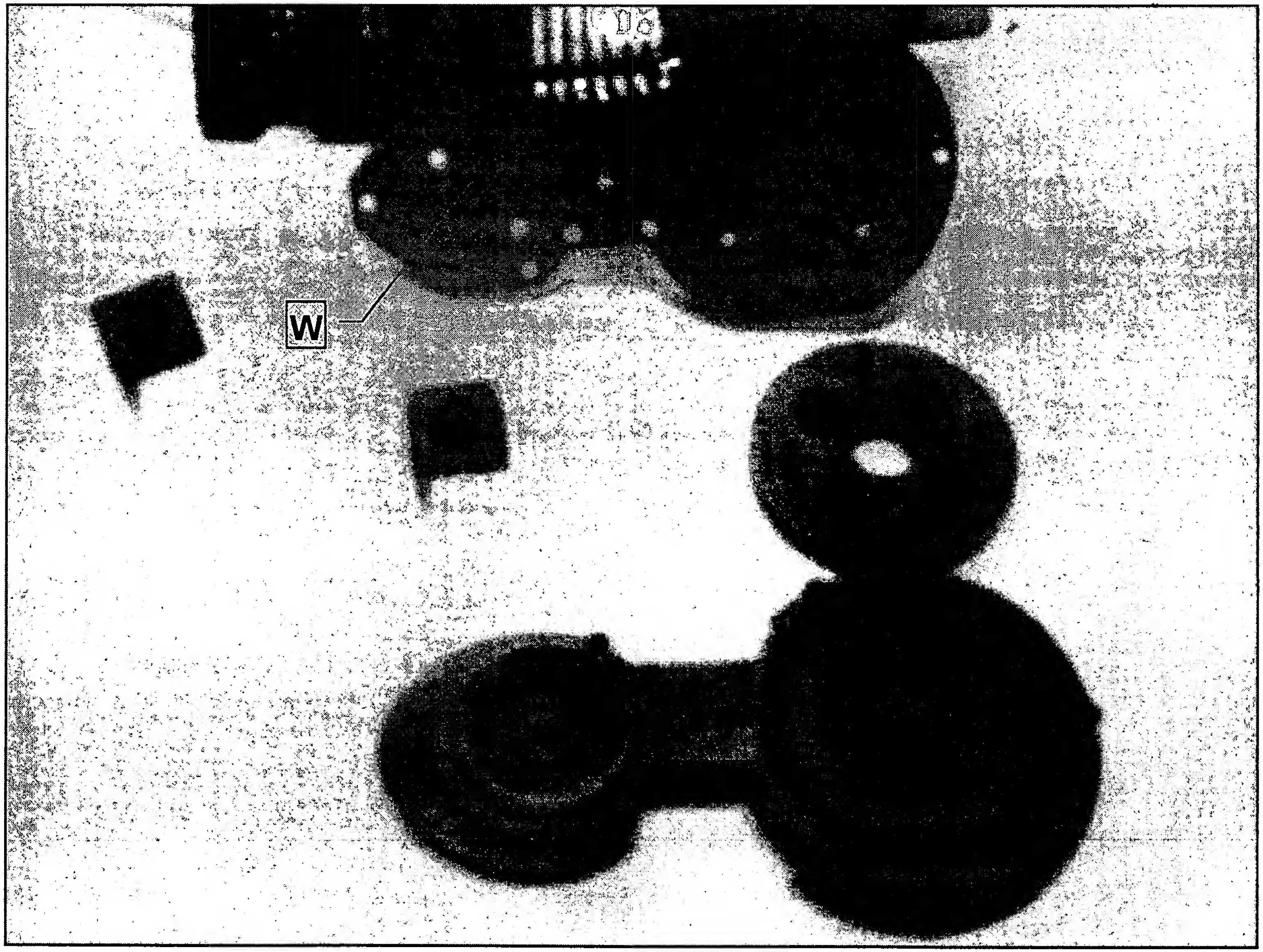
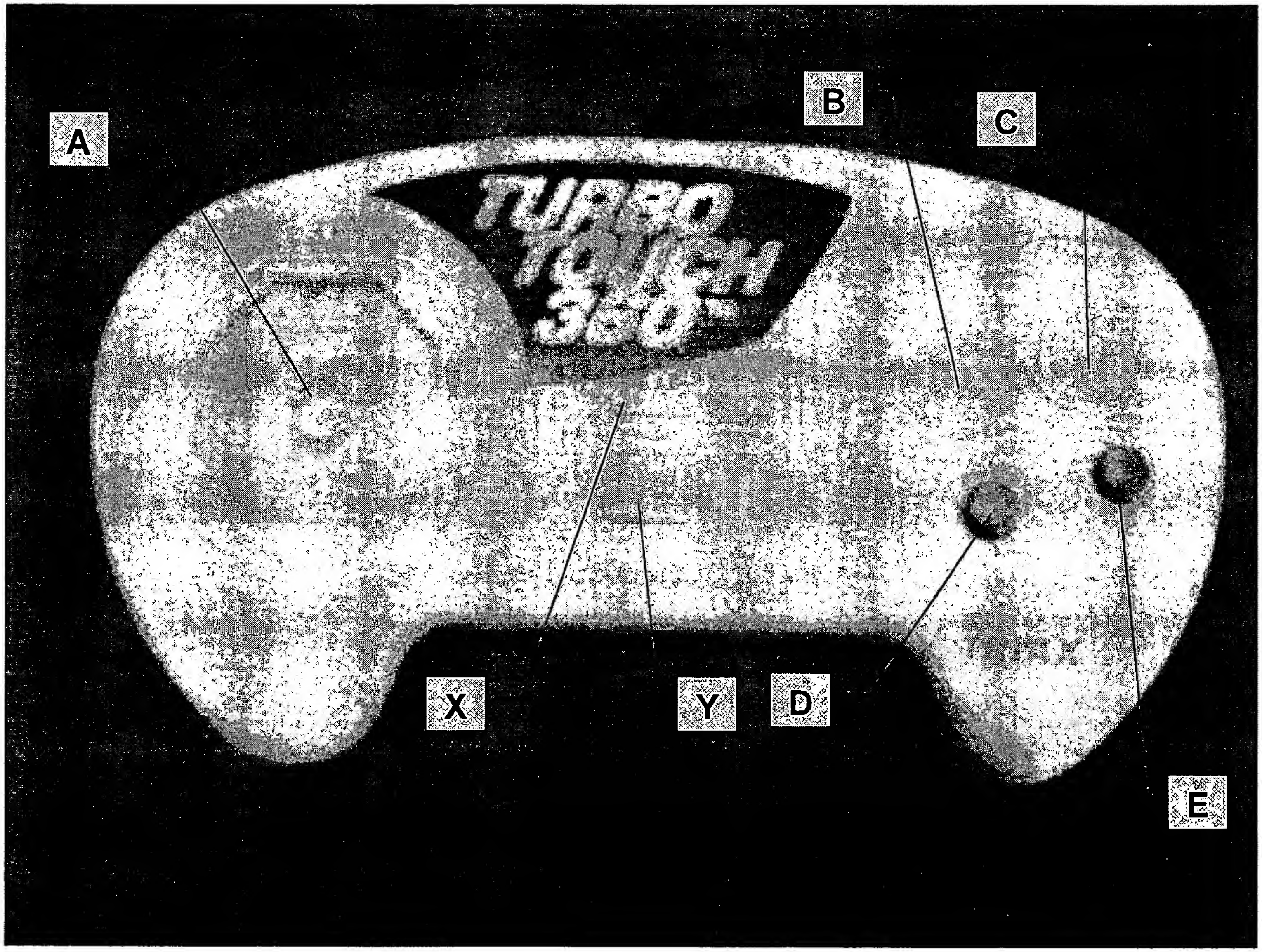
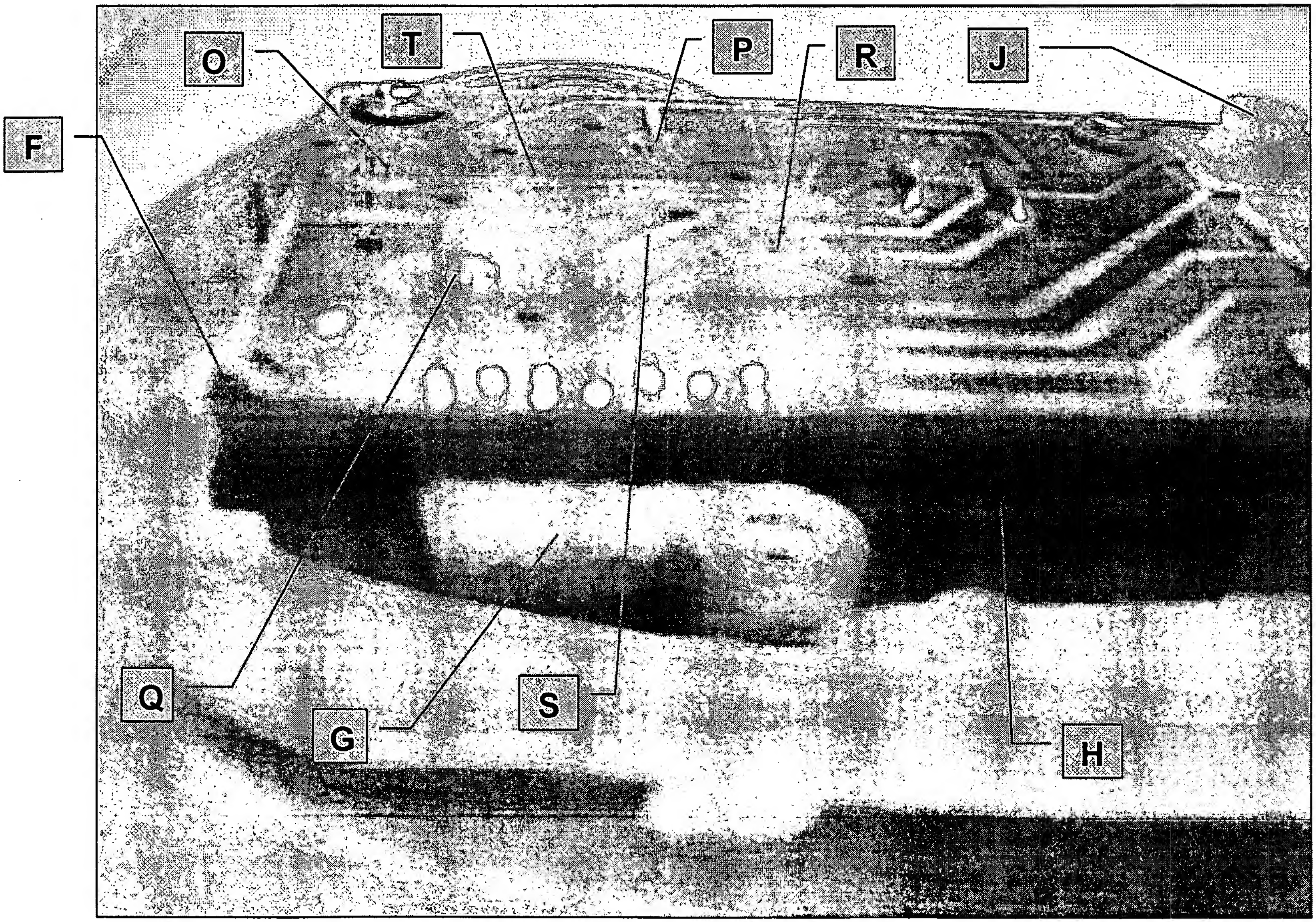


Turbo Touch 360 Controller

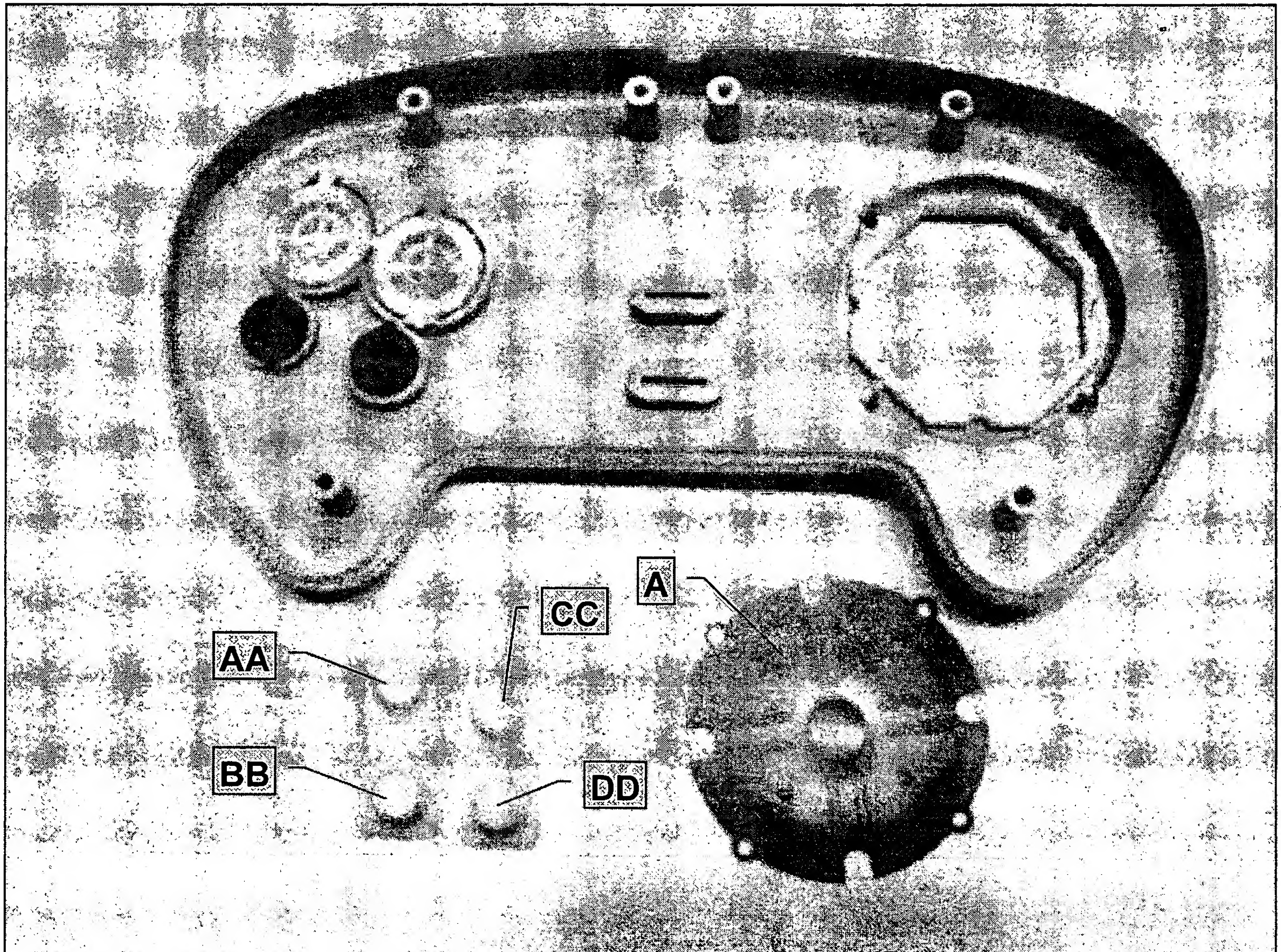


Turbo Touch 360 Controller

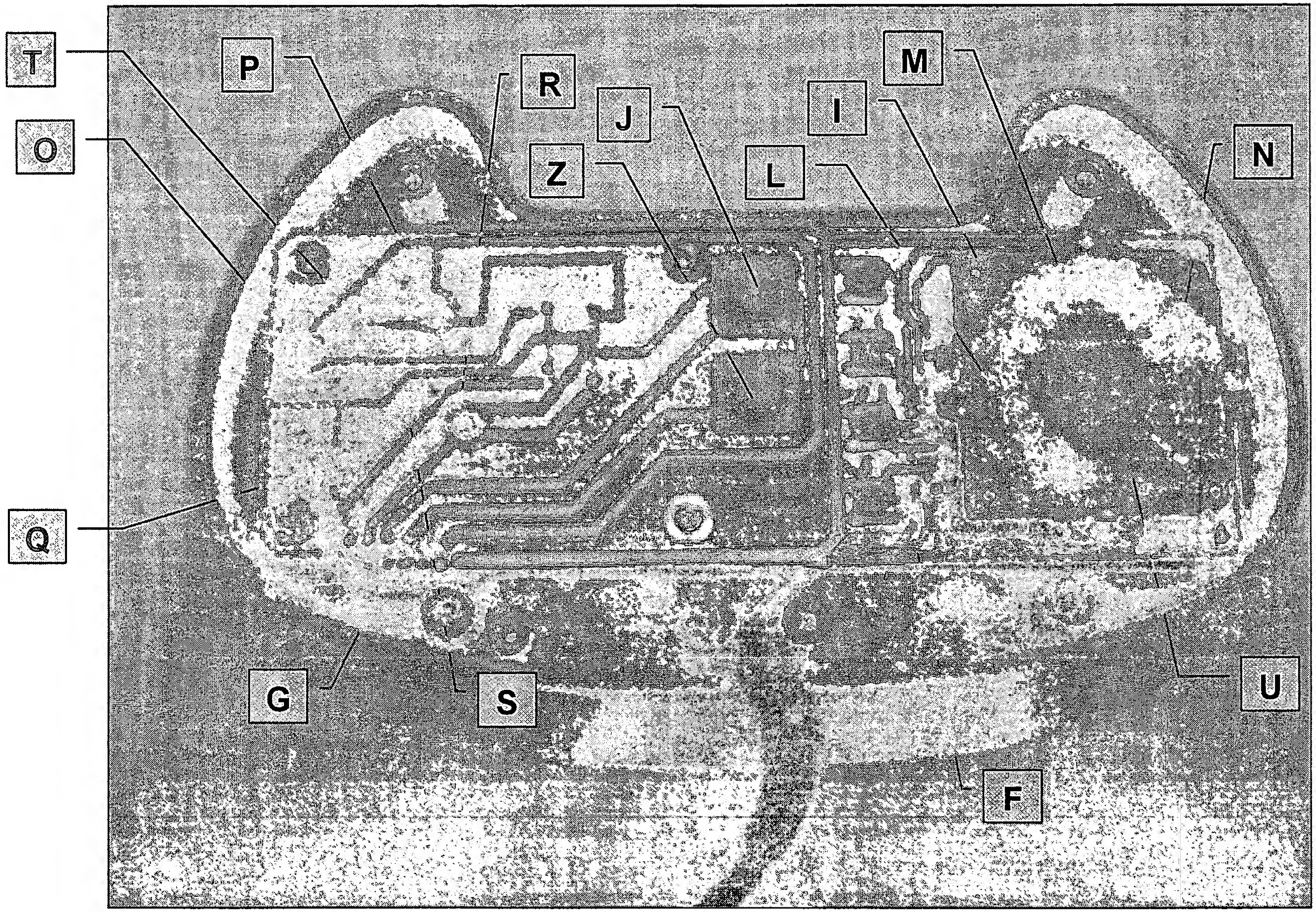


Turbo Touch 360 Controller

Turbo Touch 360 Controller



Turbo Touch 360 Controller



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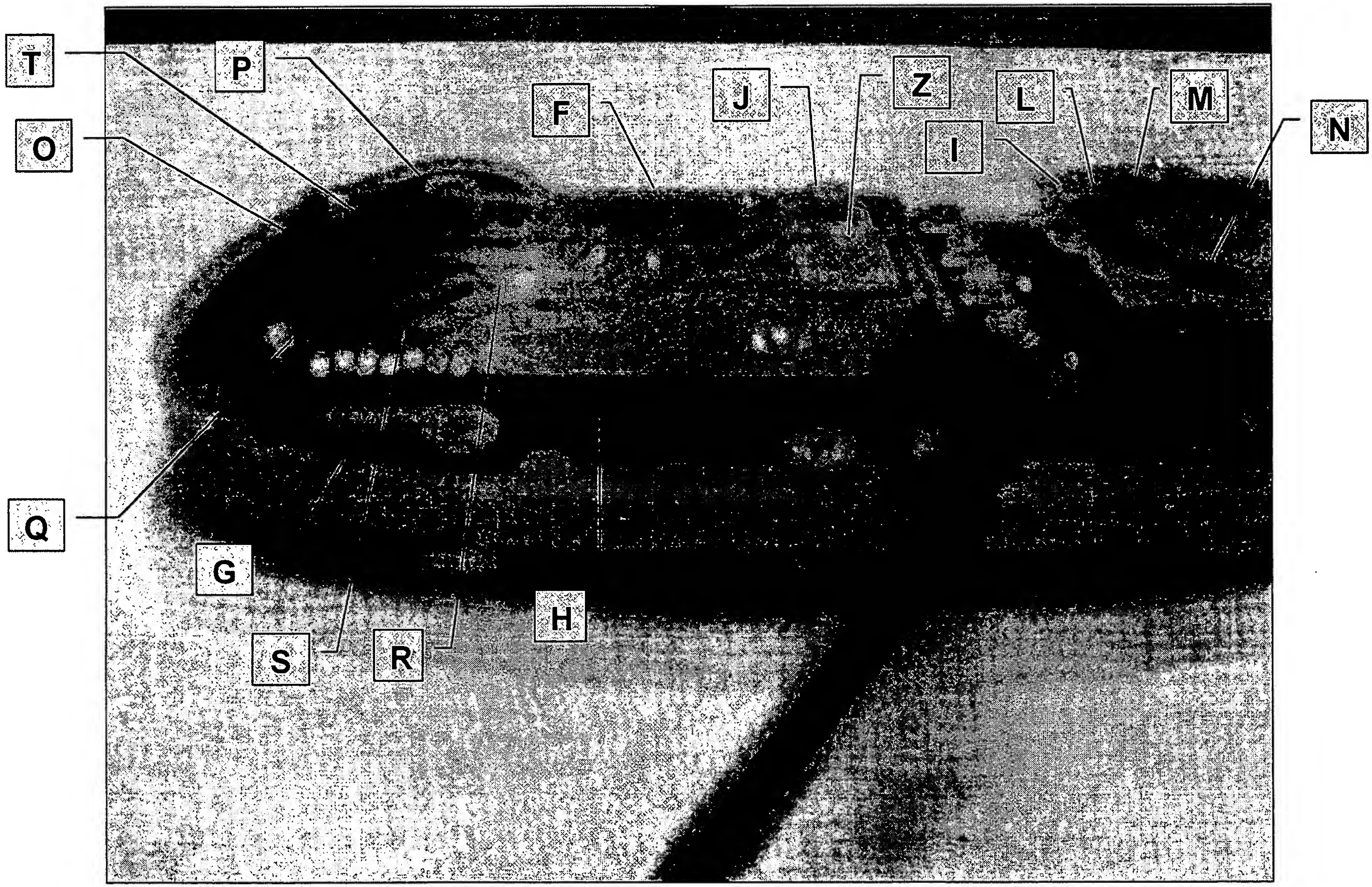
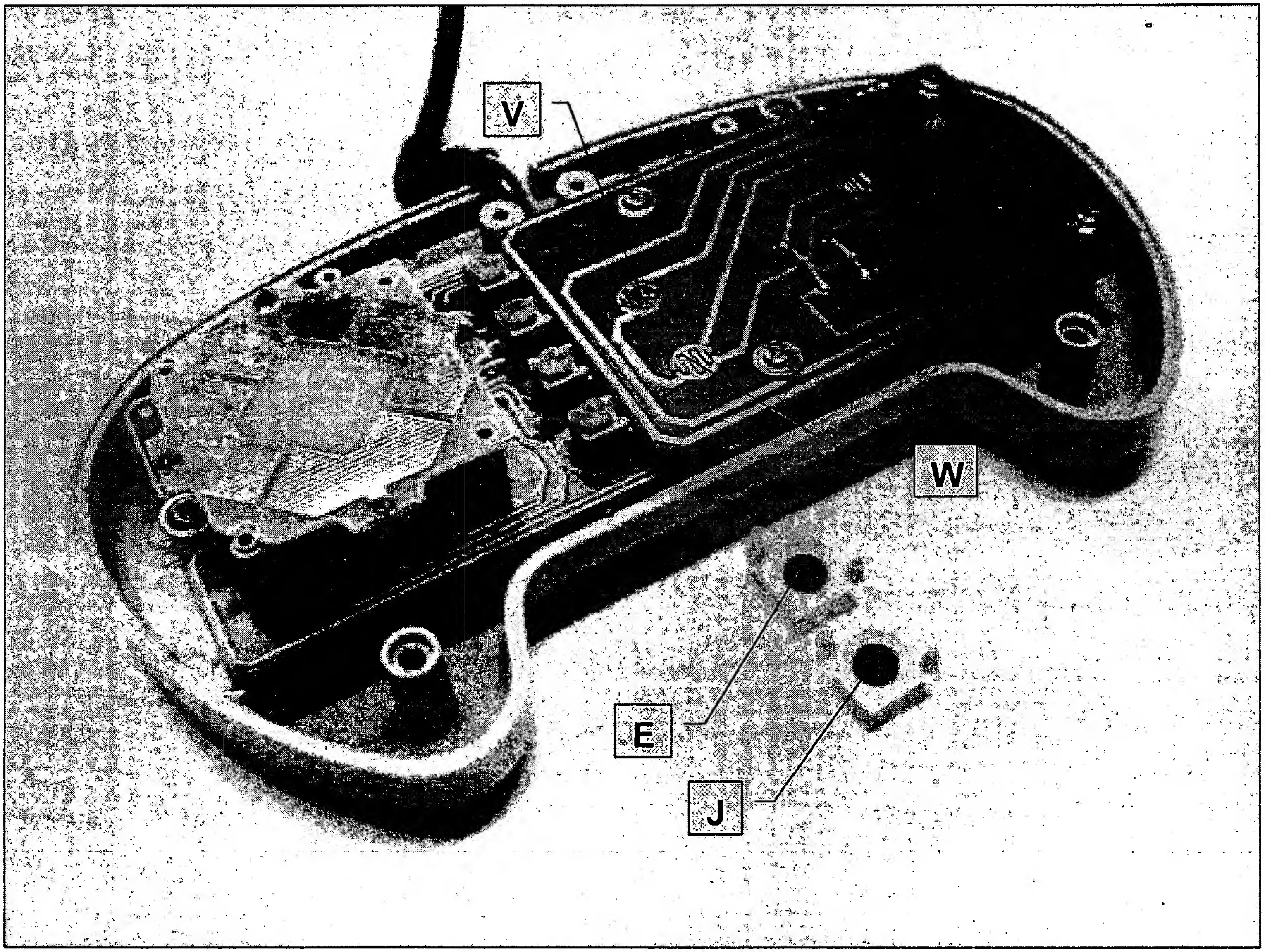
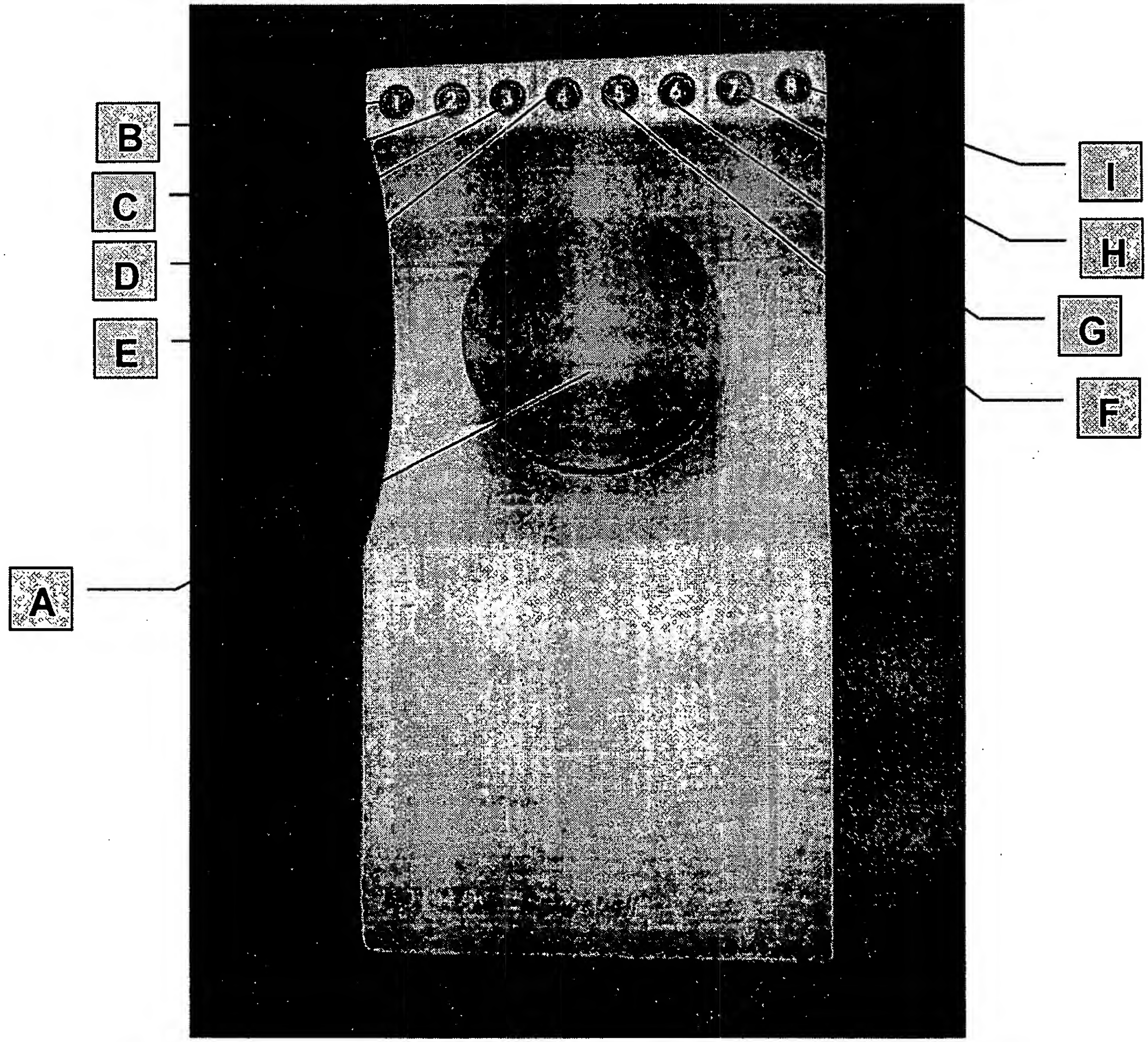


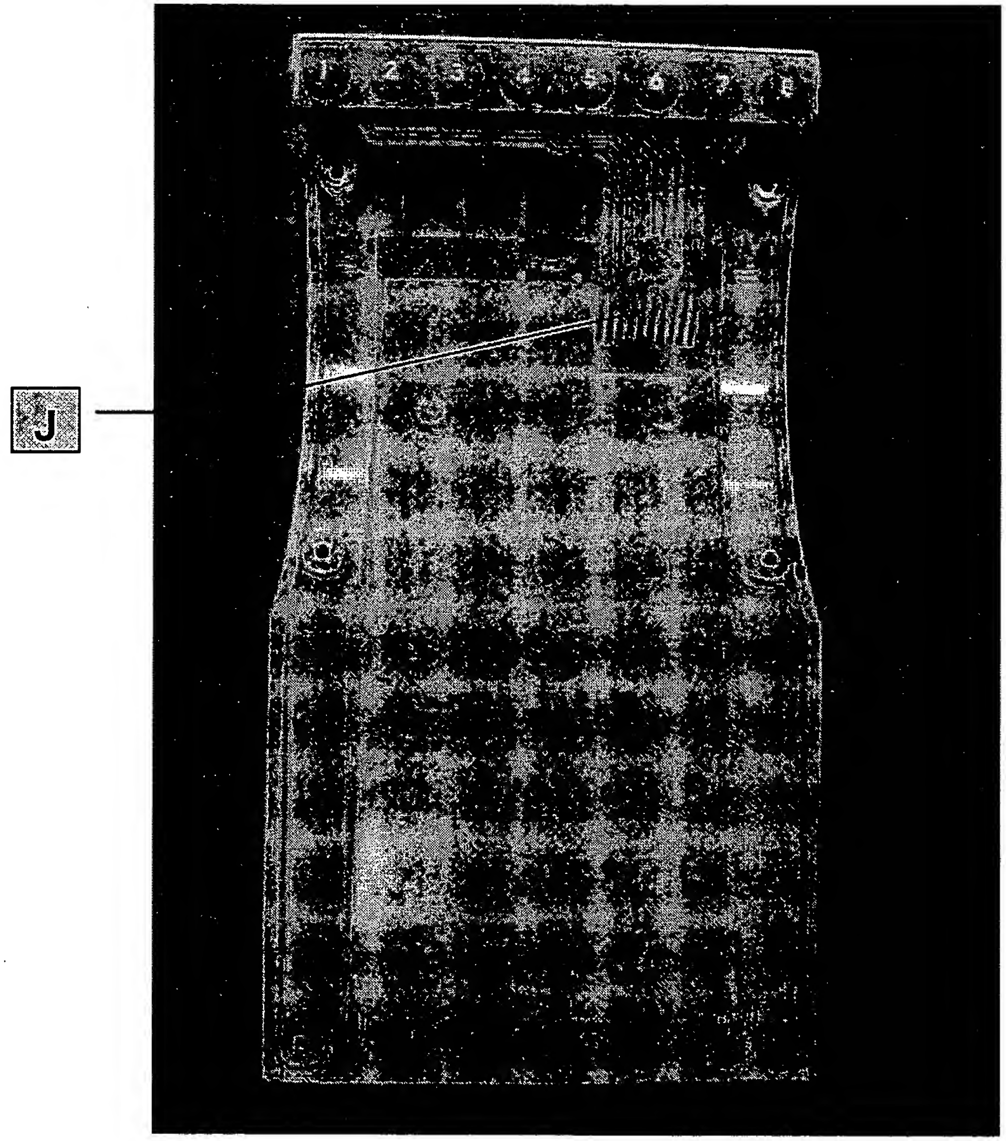
Turbo Touch 360 Controller



Spaceball Controller



Spaceball Controller



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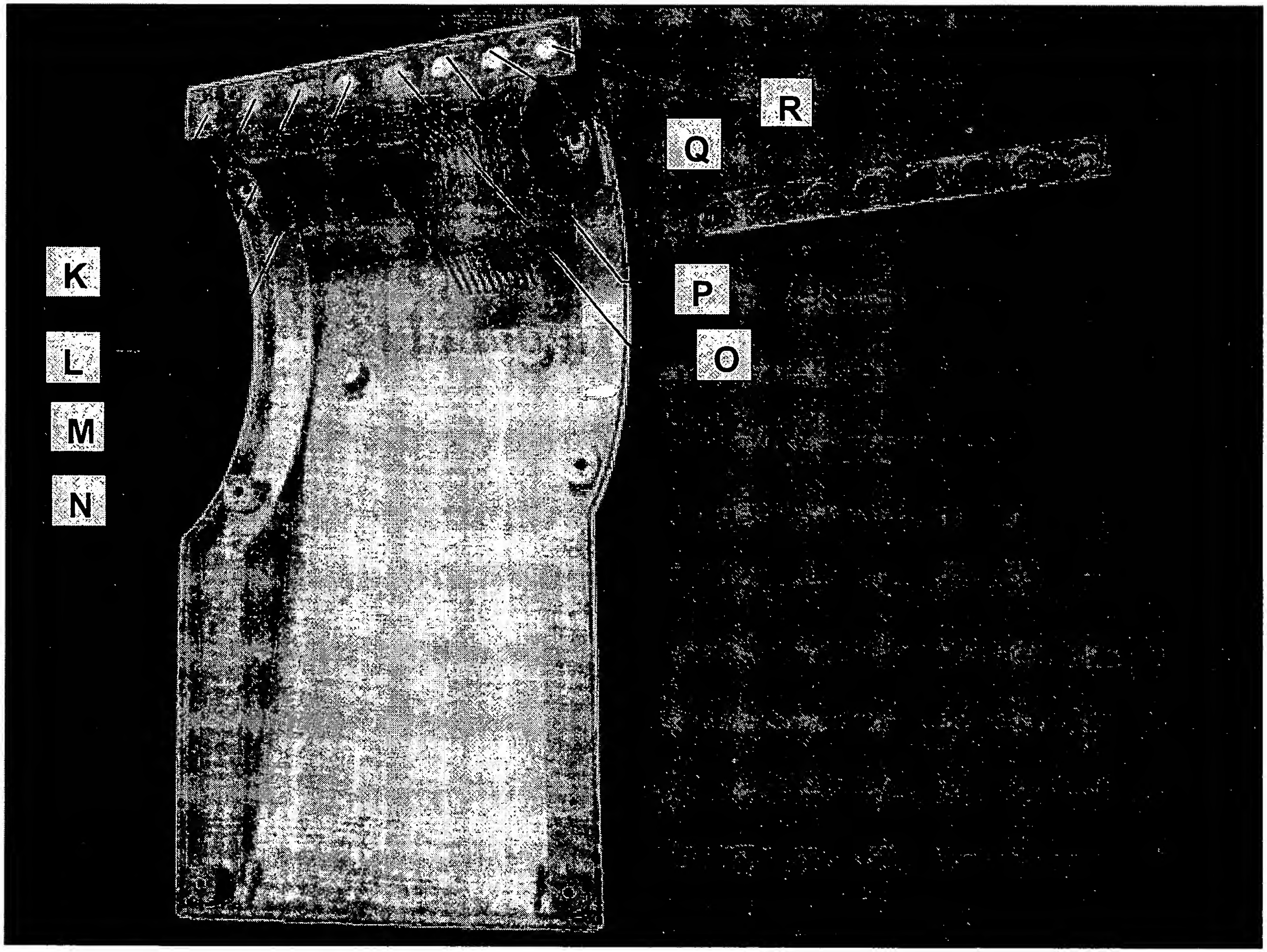

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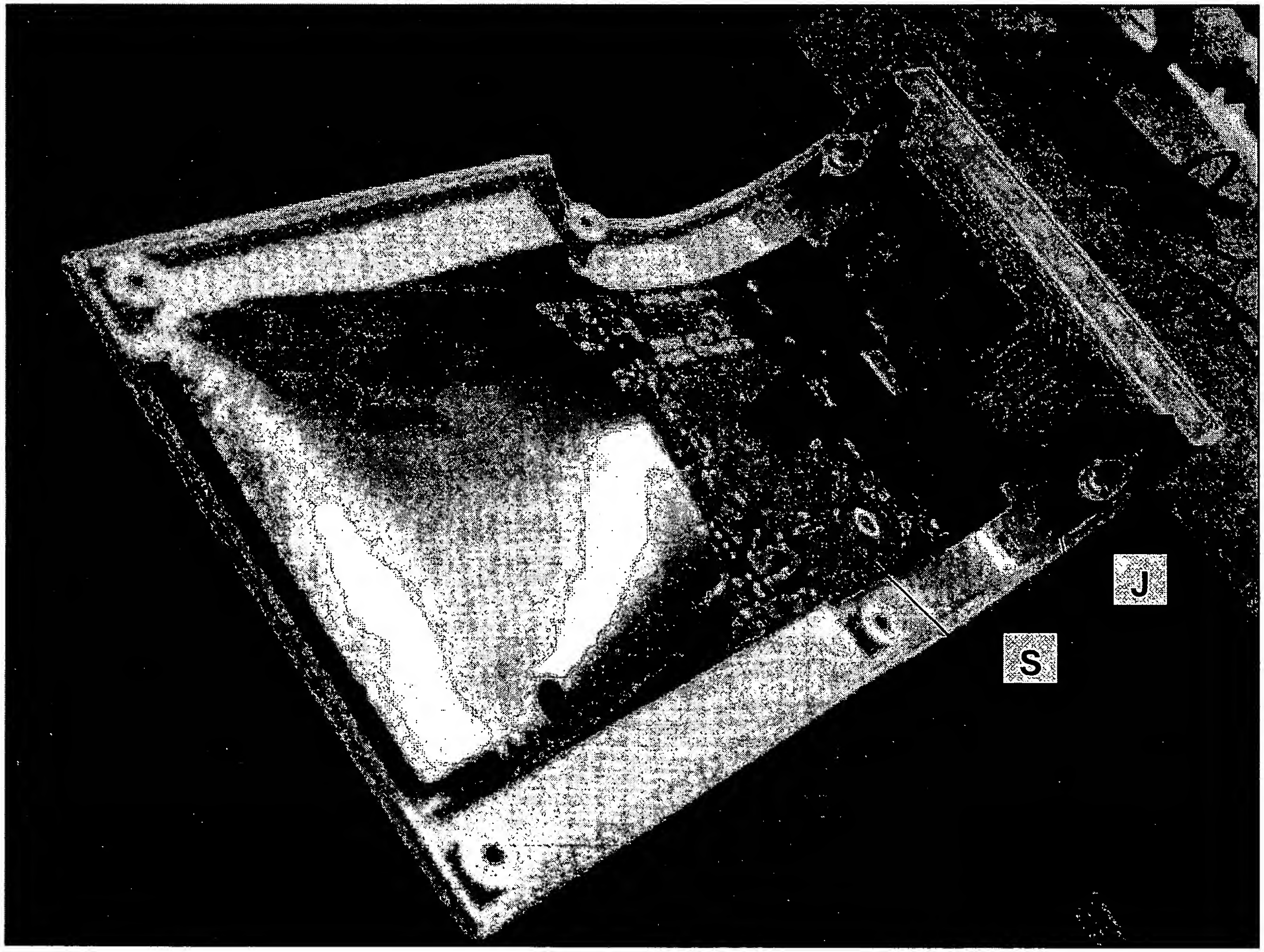
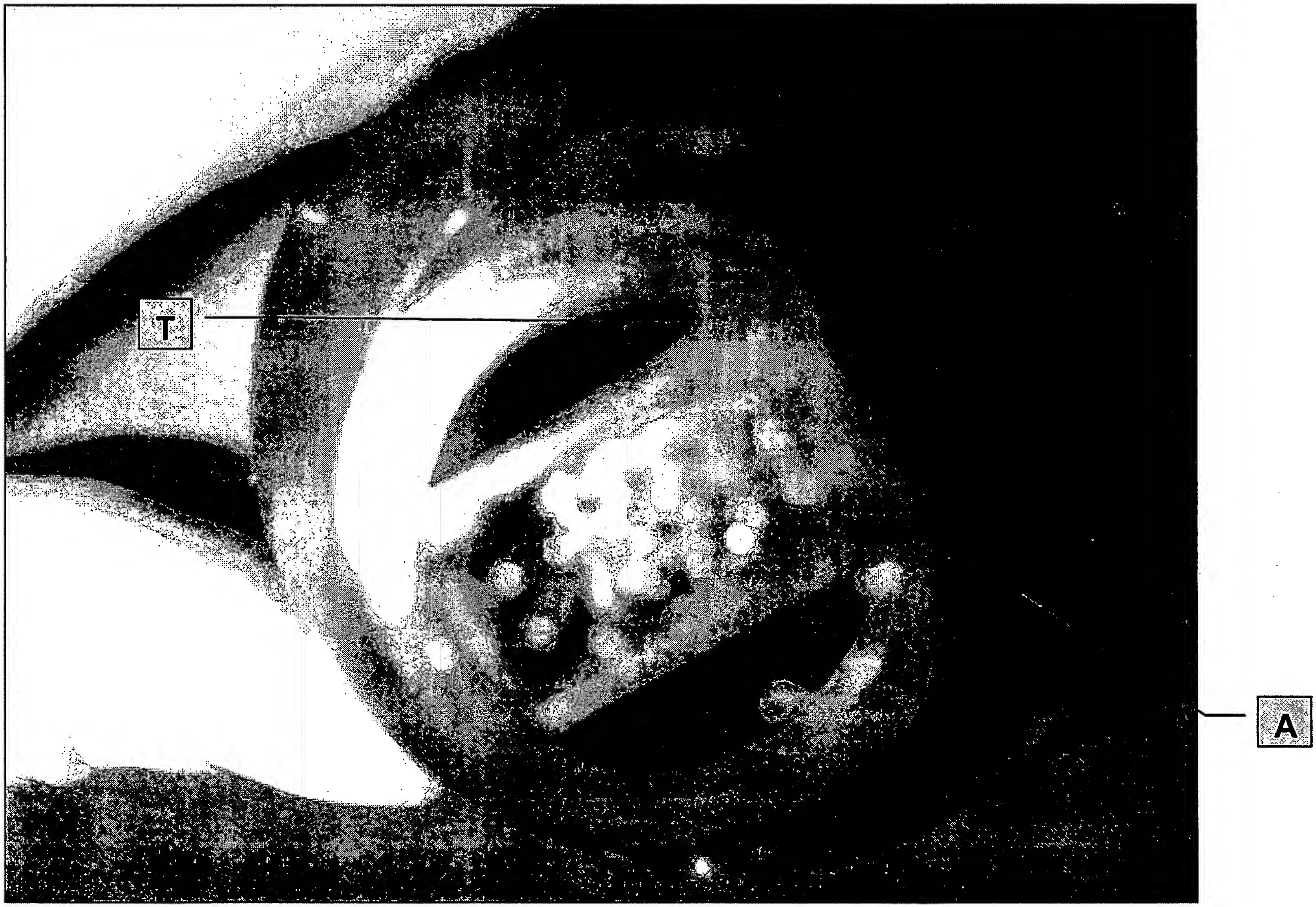


Spaceball Controller



DESIGN SPECIFICATIONS FOR MEMBRANE KEYBOARDS

CSI KEYBOARDS, INC

56 PULASKI STREET, PEABODY, MASS., 01960 TEL (508)532-8181 FAX (508)532-2957

Contents

Micro-Motion Flat Membrane Keyboard

1.1 Micro-Motion Flat Membrane Keyboard

The micro-motion flat membrane keyboard is the standard non-tactile keyboard and consists of the following components:

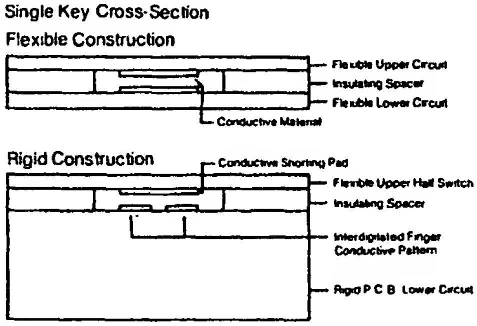
- A flexible upper circuit layer
- A flexible or rigid (PCB) lower circuit layer
- An insulating spacer layer
- A graphic overlay

The upper circuit layer is flexible polyester film and the lower circuit can either be flexible or rigid (PCB). The two circuit layers are separated by an insulating spacer layer with openings cut at key locations. Pressure applied to a key location flexes the upper circuit through the spacer opening bringing it in contact with a lower circuit, producing a momentary switch closure.

The following illustrations show the positioning of the various components and highlight the differences between flexible and rigid construction:

Micro-Motion/Flat Membrane

Single Key Cross-Section

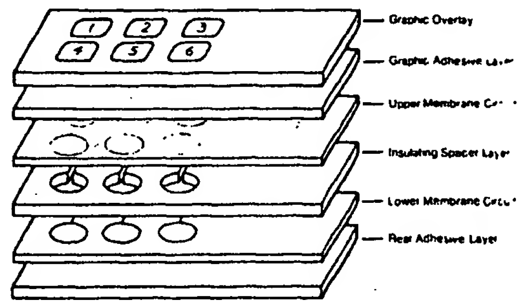


1.1.1 Materials and Bonding

The standard circuit and spacer substrate consists of polyester material. The circuit is typically a screen-printed silver ink composition. A printed circuit board with plated contacts can be used as the lower circuit layer to form a rigid backer and facilitate electronic component assembly. Alternate contact materials include carbon or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

A graphic overlay mounted to the top of the upper circuit designates key locations. The overlay usually is either polyester or polycarbonate material.

Micro-Motion Flat Membrane



It is strongly recommended that all keyboards be environmentally sealed with laminate acrylic adhesives. However, manufacturing costs can be lowered by using ultrasonic welding or heat staking to secure the switch layers

1.1.2 Contact Materials

Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

1.1.3 Standard Switch Travel

Standard switch travel is .008". However, travel varies according to spacer thickness. Minimum switch travel is .005".

Note

Switch travel is defined as the distance travelled by the upper circuit from its resting position to the point of contact with the lower circuit.

1.1.4 Standard Thickness

Typical thickness for a flexible switch with a graphic overlay is .044". If a .062" rigid PCB lower circuit is used, then standard thickness is .093".

The following considerations affect the total thickness of the keyboard:

- The type of lower circuit and the rear adhesive mounting system.
- The thickness of the spacer layer which determines switch travel.
- Adhesive-sealed keyboards with a graphic overlay are typically .005" thicker. This additional thickness is due to the adhesive itself.

Actual keyboard thickness varies depending on customer specifications and requirements.

1.1.5 Actuation Force

Actuation force of a micro-motion flat membrane keyboard is typically specified between 4 and 8 ounces, allowing for a tolerance of ±2 ounces. Keep in mind that tight tolerance and/or low actuation forces can be achieved, but require hard tooling and design modifications.

The actuation force required to operate a switch is a function of the diameter of the switch opening cut in the spacer between the upper and lower circuits and the spacer layer thickness.

1.1.6 Standard Tooling and Tolerance
The micro-motion flat membrane keyboard is typically tooled using steel rule dies. This method results in dimensional tolerances of ± .010" To achieve dimensional tolerances of ± .005" more expensive male/female hard tooling must be employed.

1.1.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

1.1.8 Contact Bounce
Contact bounce for a flexible membrane is typically 5 milliseconds or less. A rigid lower PCB improves contact bounce time. In addition, contact materials such as gold plate further reduce contact bounce.

1.1.9 Encoding
In most cases, the following circuit layouts can be used:

- x-y
- Common buss
- 2 pole
- 3 pole
- 4 pole

1.1.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.1.11 Life Expectancy
Micro-motion flat membrane keyboards will meet or exceed ten million closures.

Tactile Membrane Keyboard/Plastic

1.2 Tactile Membrane Keyboard
The tactile membrane keyboard resembles the micro-motion flat membrane construction except that the upper circuit is domed. The tactile membrane keyboard consists of the following components:

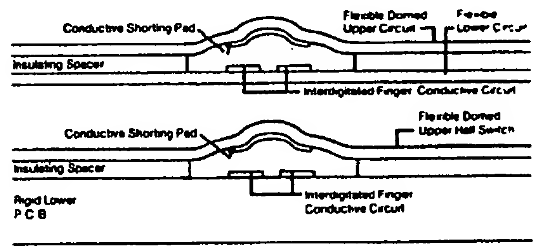
- A domed upper circuit layer
- A flexible or rigid (PCB) lower circuit layer
- An insulating spacer layer
- A graphic overlay

Pressure applied to the raised key location causes the protrusion in the upper circuit to flex through the spacer opening. This action results in a momentary switch closure and simultaneous tactile feedback.

The following figures show the positioning of the various components of the tactile membrane keyboard and highlight the differences between flexible and rigid construction:

Tactile/Membrane/Plastic

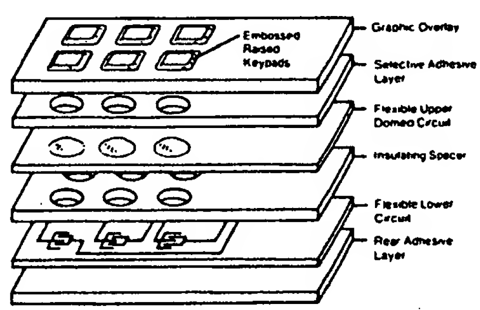
Single Key Cross-Section



1.2.1 Materials and Bonding
The standard circuit and spacer substrate consists of polyester material. The circuit is typically a screen-printed silver ink composition. A printed circuit board with plated contacts can be used as the lower circuit layer to form a rigid backer and facilitate electronic component assembly. Alternate contact materials include carbon or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

A graphic overlay mounted to the top of the upper circuit is embossed at key locations. The overlay usually is either polyester or polycarbonate material.

Tactile-Membrane Keyboard Assembly



It is strongly recommended that tactile membrane keyboards be environmentally sealed with laminate acrylic adhesives. However, manufacturing costs can be lowered by using ultrasonic welding or heat staking to secure the switch layers.

1.2.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

1.2.3 Standard Switch Travel
Maximum switch travel is .032" and minimum travel is .020", dome height ranges from .017" to .033" depending on the actuation force and travel requirements. Typical dome height is .025".

1.2.4 Standard Thickness
Typical thickness for a flexible switch with a graphic overlay is .056". If a rigid PCB lower circuit is used, then standard thickness is .105".

1.2.5 Actuation Force
Actuation force of this switch is typically 8 to 12 ounces, allowing for a tolerance of ±2 ounces.

Actuation forces significantly under 8 ounces sacrifice the snap action. Travel remains unaffected, however, producing a softer feel.

1.2.6 Standard Tooling and Tolerance
The tactile membrane keyboard is typically tooled using steel rule dies. This method results in dimensional tolerances of ± .010". To achieve dimensional tolerances of ±.005", a more expensive male/female hard tooling must be employed.

In addition, upper circuit doming requires match mold sets which increase tooling costs. Moreover, when a graphic overlay is included, an embossing tool must be used to raise the keypad on the graphics. This procedure ensures that no preload is placed on the dome.

1.2.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

1.2.8 Contact Bounce
Contact bounce is typically 5 milliseconds or less. A rigid lower PCB with optional gold contacts reduces contact bounce time.

1.2.9 Encoding
In most cases, the following circuit layouts can be used:
- x/y
- Common buss
- 2 pole
- 3 pole
- 4 pole

Note
Three and four pole switches have limitations with respect to contact bounce and density of layout. They typically require a specially shaped, injection-molded actuator.

1.2.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.2.11 Life Expectancy
Tactile membrane keyboards meet or exceed three million closures.

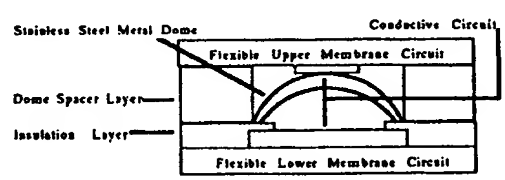
Metal Dome Membrane Keyboard

1.3 Metal Dome Membrane Keyboard

In a metal dome membrane keyboard the domes are placed on a dielectric insulating layer which has been applied to the outer perimeter of the contact on the lower membrane circuit. The dome is secured in position by the dome spacer layer. The upper membrane circuit is positioned over the dome with the conductive material of the upper circuit making contact to the dome. Pressure applied to the dome allows it travel through the dome spacer layer and make contact to the lower circuit creating a momentary switch closure. This action also produces a tactile response. (Refer to Section 6.8 for information on metal dome specifics)

The following figure shows the positioning of the various components of the metal dome membrane keyboard:

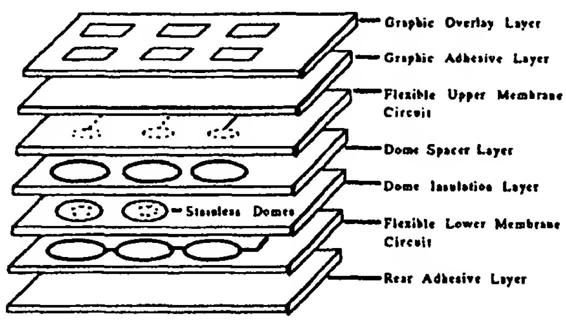
Tactile Metal Dome Flexible Membrane Switch
Single Key Cross-Section



1.3.1 Materials and Bonding
The standard upper and lower circuits and spacer substrate consist of polyester material while the metal domes are made of stainless steel. The circuit is typically a screen-printed silver ink composition. A printed circuit board with plated contacts can be used as the lower circuit layer to form a rigid backer and facilitate electronic component assembly. Alternate contact materials include carbon or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

A graphic overlay mounted to the top of the upper circuit may be embossed at key locations. The overlay usually consists of either polyester or polycarbonate.

Tactile Metal Dome Over Flexible Membrane Switch



It is strongly recommended that all keyboards be environmentally sealed with laminate acrylic adhesives. Lower cost unsealed assemblies use ultrasonic welding or heat staking.

1.3.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

1.3.3 Standard Switch Travel
Switch travel is typically .020".

1.3.4 Standard Thickness
Thickness varies between .053" and .081", depending on customer requirements.

1.3.5 Actuation Force
Actuation force of this switch is typically 10 to 14 ounces, allowing for a variation rate of ± 2 ounces.

Actuation forces significantly under 8 ounces lose their snap action. Travel remains unaffected, however, producing a softer feel.

Note:
Extreme temperatures result in variation in the feel of the keyboard.

1.3.6 Standard Tooling and Tolerance
The metal dome membrane keyboard is tooled using steel rule dies. This method results in dimensional tolerances of $\pm$ .010". To achieve dimensional tolerances of $\pm$ .005", a more expensive male/female hard tooling must be employed.

Moreover, when a graphic overlay is included, an embossing tool must be used to raise the keypad on the graphics.

1.3.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

1.3.8 Contact Bounce
Metal dome keyboards have a contact bounce of less than 5 milliseconds. Optimum results are achieved by using gold contacts, which in turn reduce contact bounce time. Minimum contact bounce is 1 millisecond.

1.3.9 Encoding
In most cases, the following circuit layouts can be used:

- x/y
- Common buss
- 2 pole

1.3.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.3.11 Life Expectancy
Metal dome membrane keyboards meet or exceed three million closures.

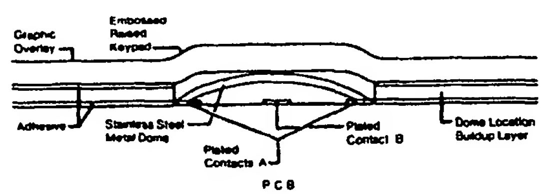
Tactile Metal Dome/PCB Keyboard

1.4 Tactile Metal Dome/PCB Keyboard
A tactile metal dome/PCB keyboard uses snap-action metal domes over contacts on a printed circuit board. When pressure is applied to a key location, the dome flexes and shorts the outer and inner PCB contacts. This action simultaneously produces a momentary switch closure and tactile feedback.

The following figure shows the positioning of the various components of the tactile metal dome/PCB keyboard:

Tactile Metal Dome/P.C.B.

Single Key Cross-Section



1.4.1 Materials and Bonding
A printed circuit board with plated contacts serves as the lower circuit layer. The standard PCB thickness is .062", but .032" and .092" can also be used.

The printed circuit board's contact material is typically tin/lead reflow over copper. Nickel and nickel/gold are available as options. The upper contact consists of the snappable stainless steel dome, which can be gold plated if desired.

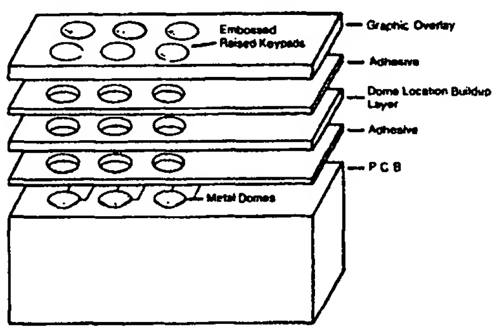
The domes are held in position in one of two ways:

1 Placed within die-cut openings in a locator layer that is adhesive-bonded to the PCB.

2 Overlaminated with adhesive-backed polyester.

A graphic overlay mounted to the top of the upper circuit designates key locations. When a graphic overlay is either not used or removable, a thin film is laminated over the dome locator layer to prevent movement of the domes.

Tactile Metal Dome/P.C.B. Assembly



1.4.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit with metal domes.

1.4.3 Standard Switch Travel
Switch travel is typically .025". Minimum travel is .020".

1.4.4 Standard Thickness
Standard thickness is typically .085".

1.4.5 Actuation Force
Actuation force of this switch is typically 12 to 16 ounces, allowing for a tolerance of 2 ounces.

Actuation forces significantly under 8 ounces lose their snap action. Travel remains unaffected, however, producing a softer feel.

1.4.6 Standard Tooling and Tolerance
The flexible layers of the metal dome/PCB keyboard are tooled using steel rule dies. This method results in dimensional tolerances of ± .010".

1.4.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

1.4.8 Contact Bounce
Metal dome keyboards have a typical contact bounce o[illegible] than 5 milliseconds.

1.4.9 Encoding
In most cases, the following circuit layouts can be used

- x/y
- Common buss
- Two pole

1.4.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 wa[illegible]

1.4.11 Life Expectancy
Metal Dome/PCB keyboards meet or exceed three million closures.

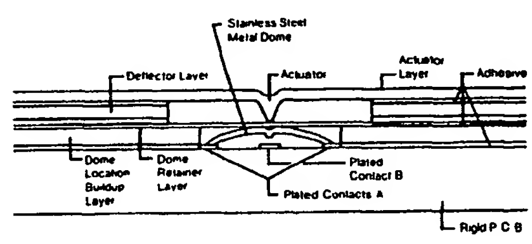
Tactile Metal Dome/PCB/Actuator Assembly

1.5 Tactile Metal Dome/PCB/Actuator Assembly
A tactile metal dome/PCB/actuator assembly adds an actuator layer to the keyboard described in Section 1.4. The actuator improves tactile feedback by centralizing pressure above a central depression on the metal dome.

The actuator layer has formed downward protrusions at key locations above the metal domes and is typically .010" thick. These protrusions make contact with the depressions on the metal domes and result in improved feedback.

The following figure shows the positioning of the various components of the assembly:

Tactile Metal Dome-P.C.B. with Actuator
Single Key Cross-Section

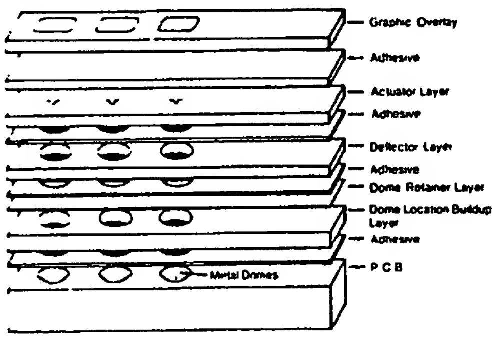


1.5.1 Materials and Bonding
The construction of this assembly resembles the metal dome/PCB keyboard.

In addition, a deflector layer is required below the formed polycarbonate actuator layer. This deflection layer provides the additional space required by the formed protrusion on the actuation layer. A dome location/buildup layer is placed beneath the deflector layer which correctly positions each metal dome on the PCB lower circuit.

The printed circuit board's contact material is typically tin/lead reflow over copper. Nickel and nickel/gold are available as options. The upper contact consists of the snappable stainless steel dome which can be gold plated if desired.

Tactile Metal Dome P C B with Actuator Assembly



Note
The graphic overlay need not be embossed in this type of construction.

1.5.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit with metal domes.

1.5.3 Standard Switch Travel
Switch travel is typically .025". Minimum travel is .020".

1.5.4 Standard Thickness
Standard thickness is typically .116". However, thickness can be varied according to customer requirements.

1.5.5 Actuation Force
Actuation force of this switch is typically 10 to 14 ounces, allowing for a variation rate of ±2 ounces.

Actuation forces significantly under 8 ounces lose their snap action. Travel remains unaffected, however, producing a softer feel.

Note:
Extreme temperatures result in variation in the feel of the keyboard.

1.5.6 Standard Tooling and Tolerance
The metal dome-PCB/actuator assembly is tooled using steel rule dies. This method results in dimensional tolerances of ± .010".

More costly male/female hard tooling can be used to achieve tolerances of ± .005". However, .005" is unusual for this assembly.

1.5.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

1.5.8 Contact Bounce
Metal dome keyboards have a contact bounce of less than 5 milliseconds.

1.5.9 Encoding
In most cases, the following circuit layouts can be used:

- x/y
- Common buss
- Two pole

1.5.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.5.11 Life Expectancy
Metal dome/PCB/actuator keyboards meet or exceed three million closures.

Tactile Floating Key Assembly

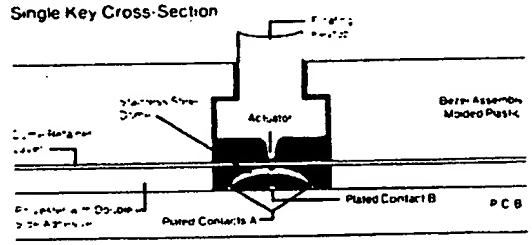
1.6 Tactile Floating Key Assembly
The tactile floating key assembly uses plastic keys in combination with either tactile membrane or metal dome switches. The keys are contained in a bezel or frame that is positioned over the switches.

The type of dome selected depends upon cost, life expectancy, and touch requirements.

The following figure shows one design of the tactile floating key assembly using a metal dome switch.

Tactile Floating Keytop

Single Key Cross-Section



1.6.1 Actuator
In either a tactile membrane or metal dome design, the actuator must be integral to the key itself. The polyester dome switch requires a round, flat actuator. In contrast, a metal dome must have a pointed actuator positioned over the depression in the dome's center.

1.6.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit with metal domes.

1.6.3 Standard Switch Travel
Switch travel is typically .028" for a tactile membrane design and .025" for a metal dome design.

1.6.4 Standard Thickness
The thickness of the housing that holds the keys in position greatly influences the overall thickness of the assembly. In addition, thickness of a tactile membrane or metal dome switch assembly also depends on the type of lower circuit selected (flexible polyester or PCB), as well as the backer layer.

The standard thickness of a metal dome switch assembly without the the plastic frame is .087".

The standard thickness of a flexible polyester dome switch assembly without a backer is .053". (A typical backer thickness is .125".)

The standard thickness of a polyester dome switch assembly with a rigid PCB lower circuit is .105".

1.6.5 Actuation Force
Actuation force conforms to the standard for a polyester and metal dome switch assembly discussed in Sections 1.2 and 1.5. The characteristics of the floating keyboard make it much easier to vary the tactile feedback of the unit.

1.6.6 Standard Tooling and Tolerance
The tactile membrane and metal dome switch assemblies are tooled using steel rule dies. This method results in dimensional tolerances of ±.010".

More costly male/female hard tooling must be used to achieve dimensional tolerance of ±.005". In addition, the snap-action protrusions on polyester dome assemblies require match mold sets, increasing tooling costs.

1.6.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

Note
Extreme temperatures vary the actuation force and feel of the keyboard.

1.6.8 Contact Bounce
Contact bounce conforms to the standard for tactile membrane and metal dome switches as discussed in Sections 1.2 and 1.5.

1.6.9 Encoding
In most cases, the following circuit layouts can be used with tactile membrane dome switches:

- x/y
- Common buss
- 2 pole
- 3 pole
- 4 pole

Note
Three and four pole circuits often require a specially shaped actuator. In addition, they have limitations placed upon contact bounce and density of layout.

Metal dome switches can use the following circuit layouts:

- x/y
- Common buss
- 2 pole

1.6.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt

1.6.11 Life Expectancy
A tactile floating key assembly conforms to the standard for tactile membrane (3 million closures) and tactile metal dome (3 million closures).

Tactile Floating Actuator

1.7 Tactile Floating Actuator with Graphics Assembly
This assembly is either a metal dome or tactile membrane switch that has electronic components mounted between the graphic and circuit layers. A floating actuator transmits key actuation from the graphic overlay directly to the contact, thus bypassing the need for a second PCB to mount components.

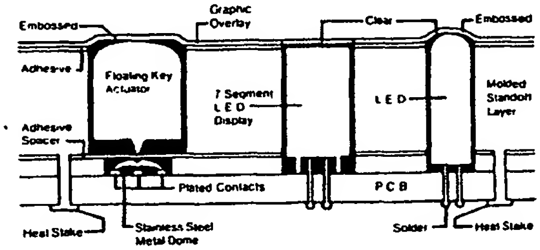
An injection-molded plastic frame provides a surface for the graphic overlay. The actuators are positioned within this frame and over each switch.

The thickness of the frame depends on the electronic components being used.

The following figure shows the design with display components mounted between the graphic and switch layers:

Tactile Floating Key Actuator/with Graphics

Single Key Cross-Section with LED Components Top Surface Mounted On P.C B



1.7.1 Actuator Design
This assembly is usually used with metal dome, rather than polyester dome switches for cost consideration. High volume applications are better accommodated by using polyester domes in conjunction with a living hinge actuator. (See Section 1.9 for more detail.)

1.7.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit with metal domes

1.7.3 Standard Switch Travel
Switch travel is typically .025" with metal domes and .028" when a tactile membrane design is used.

1.7.4 Standard Thickness
Keyboard thickness depends largely on the type of the actuators required and whether the keyboard is a tactile membrane or metal dome.

PCB thickness is usually .062" in these products.

Standard thickness for a metal dome keyboard without a plastic frame is .087".

Standard thickness for a polyester dome keyboard with a rigid PCB is .095".

1.7.5 Actuation Force
Actuation force is 12 ounces ± 2 ounces for tactile membrane switches and 16 ounces ± 2 ounces for metal dome switches. The characteristics of the floating keyboard make it much easier to vary the feel of the unit.

1.7.6 Standard Tooling and Tolerance
Metal dome and tactile membrane switch assemblies are tooled using steel rule dies. This method results in dimensional tolerances of $\pm$ .010".

More costly male/female hard tooling must be used to achieve dimensional tolerances of $\pm$.005".

The domes on the tactile membrane switch require match mold sets, increasing tooling costs somewhat. Injection molding tooling is also necessary.

1.7.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

Note
Extreme temperatures cause the actuation force and feel of the keyboard to vary.

1.7.8 Contact Bounce
Contact bounce conforms to the standard for tactile membrane and metal dome keyboards. Refer to Sections 1.2 and 1.5.

1.7.9 Encoding
In most cases, the following circuit layouts can be used with polyester dome switches:

- x/y
- Common buss
- 2 pole
- 3 pole
- 4 pole

Note
Three and four pole circuits often require a specially shaped actuator. In addition, they have limitations placed upon contact bounce and density of layout.

Metal dome switches can use the following circuit layouts:

- x/y
- Common buss
- Two pole

1.7.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.7.11 Life Expectancy
A tactile floating key assembly conforms to the standard for tactile membrane (3 million closures) and tactile metal dome (3 million closures)

Tactile Living Hinge Key Assembly

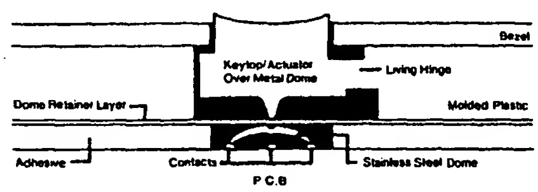
1.8 Tactile Living Hinge Key Assembly
This assembly resembles the floating key assembly described in Section 1.6. Either a tactile membrane or a metal dome switch may be used in conjunction with a frame to mount keys and actuators over the switches.

However, the key assembly is a single piece of plastic with tabs attaching the key to the frame. The tab is thinner at one point to act as a hinge, thus allowing the key to flex.

The primary advantage of a living hinge key design is that it reduces the number of parts and, consequently, assembly time.

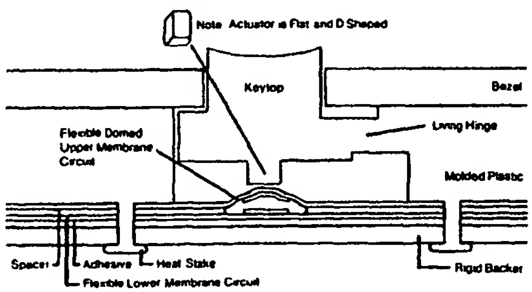
The following figures illustrate the actuator design of a living hinge keytop for use with either a tactile membrane or metal dome switch:

Tactile/Living Hinge Keytop



Keytop Actuator Over Tactile/Membrane

Single Key Cross-Section



Note
In certain applications the keyboard supplier may provide only the basic keyboard or the keyboard with the frame of keys.

1.8.1 Actuator Design
The actuator of the key used over a tactile membrane switch is D-shaped to ensure proper action. The actuator used over a metal dome, however, is pointed for proper positioning over the depression in the dome's center.

1.8.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel or nickel/gold plate in the case of a rigid lower PCB circuit.

1.8.3 Standard Thickness
Naturally, the height of the keys and the thickness of the bezel influences the overall keyboard thickness. Typical thickness is .250".

1.8.4 Standard Switch Travel
Switch travel is typically .025" with a metal dome design and .028" with a tactile membrane design.

1.8.5 Actuation Force
Actuation force is 12 ounces ± 2 ounces for tactile membrane switches and 16 ounces ± 2 ounces for metal dome switches The characteristics of the floating keyboard make it much easier to vary the feel of the unit.

1.8.6 Standard Tooling and Tolerance
The metal dome and tactile membrane switch assemblies are tooled using steel rule dies. This method results in dimensional tolerances of .010".

More costly male/female hard tooling must be used to achieve dimensional tolerance of $\pm$.005". The snappable protrusions on polyester dome assemblies require match mold sets, increasing tooling costs. In addition, injection molding is required for key assembly.

1.8.7 Operating and Storage Temperature
Operating and storage temperature ranges from $-40°C$ to $85°C$.

Note
Extreme temperatures result in variation in the feel of the keyboard.

1.8.8 Contact Bounce
Contact bounce conforms to the standard for tactile membrane (Section 1.2) and metal dome keyboards (Section 1.5).

1.8.9 Encoding
In most cases, the following circuit layouts can be used with tactile membrane switches:

- x/y
- Common buss
- 2 pole
- 3 pole
- 4 pole

Note
Three and four pole circuits often require a specially shaped actuator. In addition, they have limitations placed upon contact bounce and density of layout.

The following circuit layouts can be used with metal dome switches:

- x/y
- Common buss
- 2 pole

1.8.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.8.11 Life Expectancy
A tactile floating key assembly conforms to the standard for tactile membrane (3 million closures) and tactile metal dome (3 million closures)

Living Hinge Actuator with Graphic Assembly

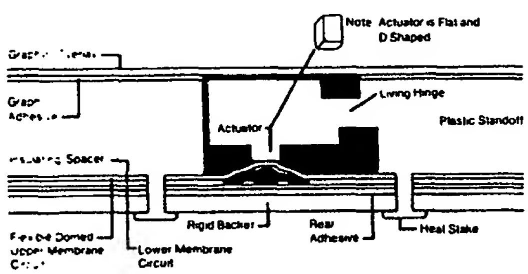
1.9 Living Hinge Actuator with Graphic Assembly
This assembly combines a tactile membrane switch assembly with a completely flat graphic overlay. Like the living hinge key assembly described in the previous section, this approach makes use of a frame assembly. However, this frame serves only as an actuator layer and does not have keytops. Instead the frame provides a mounting surface for a flat graphic overlay.

The molded actuator layer is typically heat staked to either a PCB lower circuit or a plastic backer (in the case of a flexible lower circuit).

It is not recommended that the living hinge with actuator and graphics be used with metal dome construction.

The following figure shows the design with a tactile membrane switch.

Tactile Living Hinge Actuator with Graphics



If desired, the actuator layer can be manufactured to allow electronic components to be mounted between the graphic and circuit layers. The advantages of this approach are discussed in Section 1.7.

1.9.1 Actuator Design
The actuator of the key used over a tactile membrane switch is D-shaped to ensure proper action.

1.9.2 Contact Materials
Contact materials include silver, carbon, or a silver/carbon blend when a flexible membrane is used and tin/lead, nickel, or nickel/gold plate in the case of a rigid lower PCB circuit.

1.9.3 Standard Thickness
Naturally, the thickness of the frame assembly influences the overall keyboard thickness. In addition, the type of lower circuit selected and the backer affect thickness.

A flexible polyester dome switch assembly without a backer is typically .053" thick. (Backer thickness is typically .125".)

A polyester dome switch assembly with a PCB lower circuit is typically .105" thick.

1.9.4 Standard Switch Travel
Switch travel is typically .028" for a tactile membrane.

1.9.5 Actuation Force
Actuation force is 12 ounces ±2 ounces for tactile membrane switches. The characteristics of the floating keyboard make it much easier to vary the feel of the unit.

1.9.6 Standard Tooling and Tolerance
The keyboard is tooled using steel rule dies. This method results in dimensional tolerances of ±.010".

More costly male/female hard tooling must be used to achieve dimensional tolerance of ±.005". The snappable protrusions on polyester dome assemblies require match mold sets, increasing tooling costs. In addition, injection molding is required for the living hinge frame assembly.

1.9.7 Operating and Storage Temperature
Operating and storage temperature ranges from −40°C to 85°C.

Note
Extreme temperatures result in variation in the feel of the keyboard.

1.9.8 Contact Bounce
Contact bounce conforms to the standard for tactile membrane (Section 1.2) and metal dome keyboards (Section 1.5).

1.9.9 Encoding
In most cases, the following circuit layouts can be used with tactile membrane switches:

- x/y
- Common buss
- 2 pole
- 3 pole
- 4 pole

Note
Three and four pole circuits often require a specially shaped actuator. In addition, they have limitations placed upon contact bounce and density of layout.

The following circuit layouts can be used with metal dome switches:

- x/y
- Common buss
- 2 pole

1.9.10 Electrical
The maximum circuit rating is 30V DC, 100 milliamps, 1 watt.

1.9.11 Life Expectancy
A tactile floating key assembly conforms to the standard for tactile membrane (3 million closures).

Chapter 2
Circuit Construction

Although circuit construction need not be specified to the manufacturer, you should consider the following areas when preparing an application feasibility study or cost estimate:

- Circuit encoding
- Circuit interface/termination
- Touch sensation (flat or tactile)
- Environmental requirements
- Price objectives

This chapter describes four different types of circuit construction:

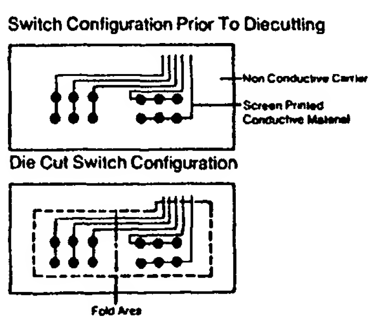
1 Single fold circuit
2 No fold circuit
3 Rigid lower circuit

2.1 Single Fold Circuit
The single fold circuit has the advantage of low cost due to the relative simplicity of the construction technique.

2.1.1 Construction
The substrate consists of a single sheet of thin, non-conductive polyester or polycarbonate material. The upper and lower circuit routings are deposited on one side of the substrate. This entire process is done in a single screen-printing operation.

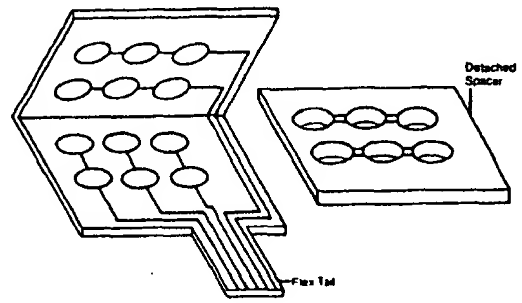
After the conductive ink has been properly cured, the entire circuit is then die cut to the specific keyboard configuration, as illustrated in the following figure:

Single Fold Circuit



Once die cut into the proper configuration, an insulating spacer layer is placed on the lower circuit and then the upper circuit is folded on top of the spacer. The three individual layers are secured by either laminate adhesives or, sonic welding or heat staking.

Single Fold Circuit



2.1.2 Closure
When pressure is applied to a switch location, the upper circuit flexes through cutouts in the spacer layer. This action results in momentary contact with the lower circuit, closing the switch.

The force required for switch closure depends on the diameter of the openings cut in the spacer layer.

The total distance travelled by the upper circuit during switch closure is determined by the thickness of the spacer layer and adhesives (if used). Upper circuit dome height of tactile membrane switches will also determine total switch travel.

Typically, internal venting channels are used to ensure air pressure equalization during switch closure. The venting channels cut into the spacer layer connect switch locations, allowing air to be shunted between groups of switch locations as necessary. (Refer to Chapter 4 for more detail.)

2.1.3 Sealing
It is highly recommended that the assembly be environmentally sealed in order to protect it against humidity, dirt, and liquid spills. Environmental sealing is achieved by applying an acrylic adhesive to both sides of the spacer layer.

Should sealed integrity be unnecessary, then heat staking or ultrasonic welding can be used to bond the three keyboard layers.

(Chapter 5 describes the process of switch bonding in detail.)

2.1.4 Electro-static Discharge
Because both the upper and lower circuits are printed on a single sheet of non-conductive material, some of the conductive routing must run across the circuit fold. This folded area is more susceptible to electro-static discharge than other areas of the keyboard.

(Chapter 8 discusses E.S.D. in detail and presents shielding alternatives.)

2.2 No Fold Circuit

The no fold circuit has two distinct advantages over the circuits already mentioned:

1 Its construction allows for less complicated circuit routing with increased circuit functions.

2 It offers better protection against environmental contaminants and electro-static discharge.

However, because of its added manufacturing time, the no fold circuit is somewhat more costly than single circuits.

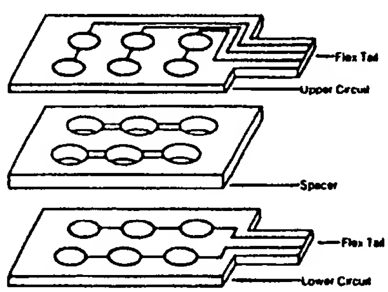
2.2.1 Construction

The no fold circuit consists of three sheets of thin, non-conductive polyester or polycarbonate material. Two of the sheets are screen-printed with conductive ink, which defines the circuit routing. These sheets serve as the upper and lower circuits.

The unprinted sheet makes up the spacer layer. Openings are cut into the spacer layer at each switch location. These spacer holes provide a point at which the upper and lower circuits can make contact.

After the conductive ink has been properly cured, the upper and lower circuits are die cut to the specific keyboard configuration. The spacer layer is then positioned over the lower circuit and the upper circuit is placed over the spacer layer. The assembly is secured either by adhesives or by sonic welding or heat staking.

No Fold Circuit



The no fold construction technique typically results in a circuit design with two separate flextails: one from the upper and lower circuit. These flextails are brought out to create one total tail width. Since the circuit traces on these tails face in opposite layers, it is recommended that a crimp through connector is used, such as a Berg single row series #65801. (Refer to Chapter 9 for more detail.)

2.2.2 Closure

When pressure is applied to a switch location, the upper circuit flexes through cutouts in the spacer layer. This action results in momentary contact with the lower circuit, closing the switch.

The force required for switch closure depends on the diameter of the openings cut in the spacer layer.

The total distance travelled by the upper circuit during switch closure is determined by the thickness of the spacer layer and adhesives (if used). Upper circuit dome height of tactile membrane switches will also determine total switch travel.

Typically, internal venting channels are used to ensure air pressure equalization during switch closure. The venting channels cut into the spacer layer connect switch locations, allowing air to be shunted between groups of switch locations as necessary. (Refer to Chapter 4 for more detail.)

2.2.3 Sealing

It is highly recommended that the assembly be environmentally sealed in order to protect it against humidity, dirt, and liquid spills. Environmental sealing is achieved by applying an acrylic adhesive to both sides of the spacer layer.

Should sealed integrity be unnecessary, then heat staking or ultrasonic welding can be used to position the three keyboard layers.

(Chapter 5 describes the process of switch bonding in detail.)

2.2.4 Electro-static Discharge

The lack of circuit folds and the use of recommended laminated acrylic adhesive bonding means that this assembly offers greater protection from electro-static discharge than folded units. Moreover, each additional layer of the construction increases the dielectric hardness of the keyboard. (Chapter 8 discusses E.S.D. in detail.)

2.3 Rigid Lower Circuit
Rigid lower circuit construction permits more complex circuit functions and the additional space on the PCB simplifies the actual circuit routing. This lower circuit typically consists of either a single or double sided printed circuit board, which enables the keyboard to incorporate metal domes and/or electronic components.

2.3.1 Construction
In this construction, a glass epoxy printed circuit board (PCB) is used as the lower circuit. For membrane keyboards, the upper circuit consists of either a polyester or polycarbonate material with construction and operation the same as previously discussed.

For metal dome keyboards, snap-action metal domes bridge the contact points on the lower PCB layer. The metal dome construction requires additional location and retainer layers to hold the domes in place. An optional actuation layer placed over the metal domes improves their snap-action.

Internal venting is also recommended, but not required for metal dome construction. Venting is achieved by cutting air channels in the location layer so that air pressure will be equalized when pressure is applied to the switch location, flexing the metal dome.

The keyboard can be enhanced by affixing electronic components to the front or rear of the PCB. These components can include integrated circuits, timers, axial light-emitting diodes, and seven segment displays.

2.3.2 Closure
For membrane keyboards, the upper circuit flexes through cutouts in the spacer layer when pressure is applied to a switch location. This action results in momentary contact with the PCB lower circuit, closing the switch.

The force required for switch closure depends on the diameter of the openings cut in the spacer layer.

The total distance travelled by the upper circuit during switch closure is determined by the thickness of the spacer layer and adhesives (if used). Upper circuit dome height of tactile membrane switches will also determine total switch travel.

Typically, internal venting channels are used to ensure air pressure equalization during switch closure. The venting channels cut into the spacer layer connect switch locations, allowing air to be shunted between groups of switch locations as necessary. (Refer to Chapter 4 for more detail.)

An alternative to a membrane upper circuit is snap-action metal domes. These domes are placed over plated contact perimeters on the PCB. Contact results when pressure is applied to the dome and it flexes to a plated contact center on the PCB.

In addition, the dome provides tactile feedback as pressure is applied and released, producing a distinct snap-action feel.

2.3.3 Sealing
It is highly recommended that the assembly be environmentally sealed in order to protect it against humidity, dirt, and liquid spills. Environmental sealing is achieved by applying an acrylic adhesive to both sides of the spacer layer, the PCB, and all associated retainer and actuator layers.

2.3.4 Electro-static Discharge
Protection against electro-static discharge can be greatly enhanced by adding laminated layers to the construction. Additional components, such as window displays or electronics, create E S D points of entry. An E.S.D. shield can be incorporated into the keyboard to alleviate the danger to internal electronics (Refer to Chapter 8 on E.S.D. protection.)

2.4 Half Switch
If the customer intends to provide a rigid PCB as the lower circuit layer, membrane manufactures will generally supply a unit consisting of only the upper circuit, spacer layer, and/or a graphic overlay for assembly to the customer's PCB. This package is referred to as a half switch.

Flat membrane and tactile membrane keyboards can be produced in half switch configurations. When assembled with the independently-supplied lower circuit, this unit functions like those described in earlier sections of this chapter.

Additional cost savings can be obtained by printing the graphics on the outer surface of a single sheet of non-conductive mater al. The upper circuit (shorting pad) is then printed on the inner surface of the same sheet. Although less costly, this method may prove to be less durable because the printed graphics are exposed to operational and environmental wear. A low cost polyester/polycarbonate over laminate may be applied over the exposed graphics to protect against wear.

Chapter 3
Encoding Techniques

Encoding is the assignment of electrical impulses to specific key locations on a membrane keyboard.

This chapter discusses the following encoding techniques:

- X/Y matrix
- Common buss
- Two pole/common
- Three pole/common
- Analog output

More information about circuit design and routing specifications can be found in Chapter 7.

3.1 X/Y Matrix
An x/y encoding matrix consists of high/low impulse leads that are arranged in rows and columns on opposite circuit layers. Each x and y intersection designates a discrete switch location.

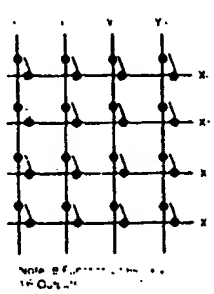
This matrix design can be used in conjunction with four constructions:

1 Single fold
2 Two fold
3 No fold
4 Metal dome

Typical X/Y Coordinance Grid

	X_0	X_1	X_2	X_3
Y	START	STOP	ENTER	RESET
Y	1	2	3	4
Y	5	6	7	8
Y	9	0	#	*

X/Y Matrix



The x/y matrix provides a maximum number of switch locations with a minimum number of termination leads.

3.2 Common Buss
Common buss encoding consists of one common (or ground) lead for all switch locations or groups of switches. Added to this is a single discrete lead or impulse line for each switch location.

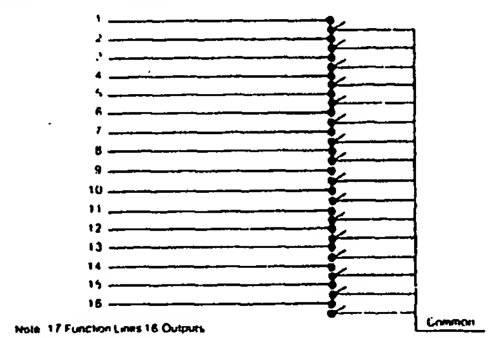
When using common buss encoding, you must consider the total circuit routing area available. Densely populated switch configurations may not provide adequate area for interface/termination exit.

The common buss design can be used in conjunction with four constructions:
1 Single fold
2 Two fold
3 No fold
4 Metal dome

Typical Common Buss Coordinance Grid

Line Input	Location	
1	START	Common
2	STOP	
3	ENTER	
4	RESET	
5	1	
6	2	
7	3	
8	4	
9	5	
10	6	
11	7	
12	8	
13	9	
14	0	
15	#	
16	*	

Common Buss

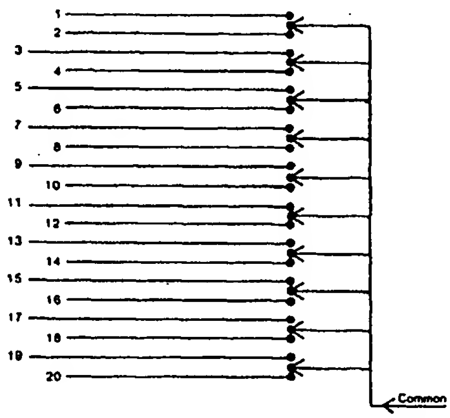


Chapter 7 contains additional design data.

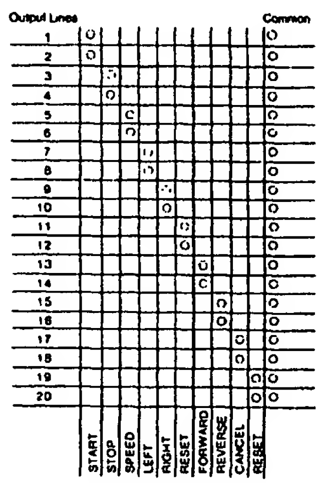
3.3 Two Pole/Common
Two pole/common encoding consists of two discrete impulses. The common may be a singular impulse for all switch locations or consist of several common groups.

When specifying two pole/common encoding, you must consider the total circuit routing area available. Densely populated switch configurations may not provide an adequate area for interface/termination exit.

Two Pole Function Lines Plus Common



Typical Two Pole Coordinance Grid



The two pole/common design can be used in conjunction with three constructions:

1 Single fold
2 Two fold
3 No fold

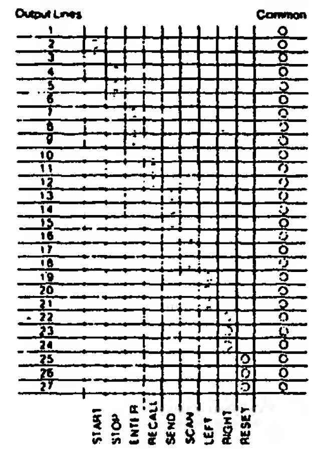
Chapter 7 contains additional design data.

3.4 Three Pole/Common
Three pole/common encoding consists of three discrete impulses for each switch location. The common may be a singular impulse for all switch locations or consist of several common groups.

When specifying three pole/common encoding, you must consider the total circuit routing area available. Densely populated switch configurations may not provide an adequate area for interface/termination exit.

The three pole/common design can be used in conjunction with three types of construction:
1 Single fold
2 Two fold
3 No fold

Typical Three Pole Coordinance Grid



Note that mechanical switch actuators may be required in three pole encodings to reduce contact bounce and/or total run time of switch closures. (See Sections 1.6, 1.7, 1.8, and 1.9 for additional information about mechanical actuators.)

As with two pole/common encoding, neither metal dome nor transparent technology can be used with three pole/common encoding.

3.5 Analog Output
Analog output consists of constant resistive values of various levels at discrete locations on a keyboard. By determining the resistance level at specific points on the keyboard, the electronic interface processor can identify a particular location.

Analog encodings are frequently used in transparent membrane technologies, which are often placed over display devices such as CRTs, plasma-gas displays, and electro-luminesent displays.

A major characteristic of an analog switch is its high resolution or switch location definition. An important factor in the resolution is also the electronic interface used. Resolution as low as .040" is possible in many cases.

Another benefit of analog is the minimum number of output lines: typically two or four. This figure depends somewhat on size and resolution requirements.

The analog output design can be used in conjunction with twc constructions:

1 Single fold
2 No fold

In addition, analog outputs can be used with non-transparent switches to produce slide-activated switches or potentiometers, scratch pads, and cursor controls.

Chapter 4
Venting

When a keypad is depressed, air pressure within the switch cavity increases. In order for the switch to close properly, air within a switch cavity must be displaced, equalizing the internal pressure.

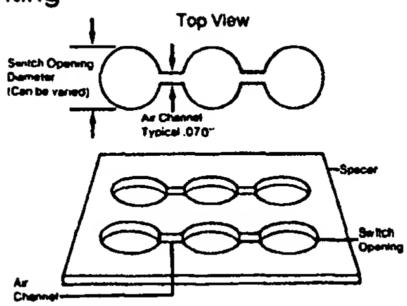
With an environmentally sealed keyboard, a laminate acrylic adhesive is used on each side of the spacer layer. However, environmental sealing traps the air in the switch cutouts of the spacer layer, meaning that the problem of equalizing this trapped air must be addressed.

Keyboards that are not environmentally sealed do not typically require venting because their open design allows air within a switch cavity to be displaced between the keyboard layers.

This chapter discusses two standard methods of venting environmentally sealed keyboards: internal and external.

4.1 Internal Venting
Environmental sealing of membrane keyboards represents an advantage over traditional mechanical switches and is strongly recommended. A sealed membrane keyboard offers increased protection from environmental contaminants such as dirt, moisture, and electro-static discharge. This seal provides for greater reliability at a relatively low cost.

Venting



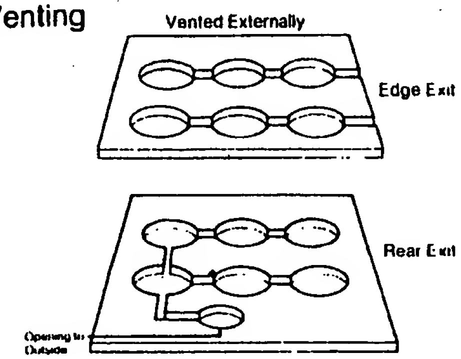
Vented Internally

4.1.1 Construction
When the keyboard has been sealed with a laminate adhesive, internal venting is required for both flat and tactile membrane constructions. Narrow channels between key location cutouts are cut in the spacer layer, permitting air from one key location to move elsewhere when that key is pressed. Note, however, that these air channels never exit to the outside of the keyboard, preventing the risk of contamination since the keyboard remains sealed.

Metal dome keyboards do not always require air channels, but may be necessary for some designs. In such cases, air channels that connect several metal dome locations are cut in the dome location layer and perform the same function as mentioned above.

4.2 External Venting
Because external venting increases the risk of contamination, it is only recommended when the keyboard will be exposed to rapid or extreme atmospheric pressure fluctuations and will not generally come into contact with a hostile environment. All types of keyboard constructions can accommodate external venting.

Venting



4.2.1 Construction
As in internal venting, narrow channels that have been cut into the spacer layer connect each key location. These channels then exit through the sides or rear of the keyboard. This design allows pressure within the switch cavities to be equalized with the surrounding atmosphere, thus allowing switch closure at any atmospheric pressure.

Non-adhesive bonded assemblies are externally vented by the nature of their construction.

4.2.2 Contamination
External venting increases the chances of environmental contamination by dust, oils, chemicals, and moisture. In particular, an electro-static discharge flashover charge of 15K volts or less may enter the external venting channel, follow the conductive circuitry, and damage sensitive internal components.

Methods of shielding against electro-static discharge are discussed in Chapter 8

Chapter 5
Switch Bonding

Switch bonding refers to the method selected for securing all independent layers of a keyboard, including the upper and lower circuits. When choosing a bonding technique, environmental considerations are important since the performance of a switch depends largely on the integrity of its bonding.

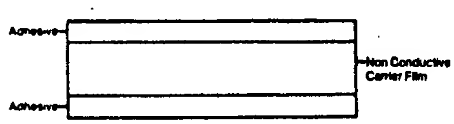
5.1 Adhesives

The acrylic adhesive group is widely accepted in membrane switch construction because of its high bond strength, performance range, and ease of application.

In a typical flat membrane construction, the pressure-sensitive acrylic adhesive is applied to both sides of the insulating spacer. This spacer is then positioned between the upper and lower circuits to provide total switch bonding.

Support Adhesive Layer

Cross-Section



Bond strength increases in relation to time and temperature. Seventy-six percent of total bond is achieved within 72 hours after the final assembly of the layers. However, the remaining or ultimate adhesion takes place during the next nine months.

Unique performance or environmental requirements may demand that special bondings be used, such as heat or chemically activated adhesives.

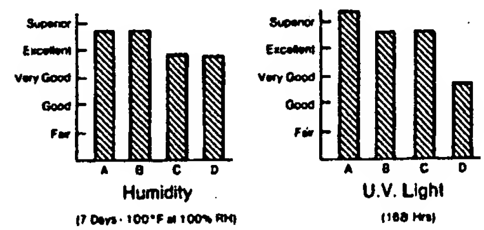
Note
When applying the adhesive, it is critical that proper surface wetting and bonding occurs. The adhesive should blow or level out to reduce the number of air bubbles. This procedure excludes contaminants and increases the protection against E.S.D. through the spacer layer.

Wetting is defined by a compatibility between the surface tension of the substrate and the adhesive.

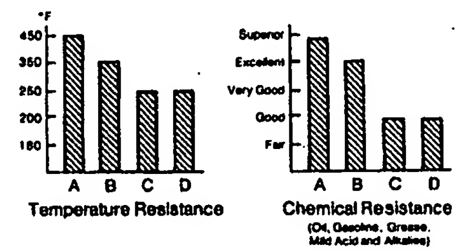
Information about proper bonding adhesives can be analyzed by referring to the following charts:

Adhesives

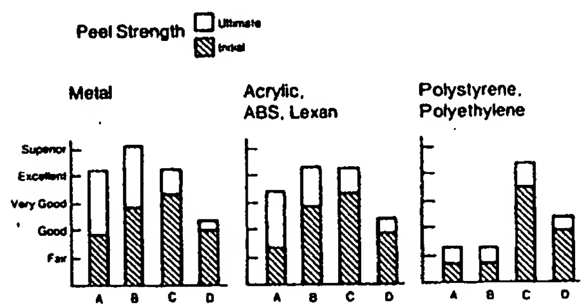
Environmental Performance



Adhesives



Adhesives



Legend
A = High Temperature
B = High Performance
C = High Strength
D = High Tack

5.2 Heat Staking

A non-adhesive bonded switch assembly can be produced by the use of heat stakes. This method can reduce the cost of the switch, but this advantage must be weighed against the loss of environmental sealing. The problems of electro-static discharge and contaminants found in the proposed operating environment should be considered before a final decision is reached.

The heat staking process involves the following steps:

1 The lower circuit, spacer layer, and upper circuit are mounted on a plastic substrate which is typically the backer or mounting surface for the switch assembly.

2 These layers are mounted over pins which have been fabricated into the rigid backer.

Holes in the upper circuit, spacer layer, and lower circuit accommodate the pins located on the plastic backer. The size of the part determines the number of pins required.

3 Heat and pressure are then applied to the pins which protrude through the switch layers. This causes the pins to melt over the upper layer, resulting in a point bonding of the switch assembly to the plastic backer.

Note that this method allows potential electro-static discharge flashover to enter between the laminates at the switch assembly perimeters. Overall switch performance and E.S.D. protection are significantly improved by concealing perimeter edges with a bezel or gasket seal.

5.3 Ultrasonic Welding

Ultrasonic welding utilizes high-frequency sound waves to bond the layers of the assembly. Consequently, no pins or plastic backer are required for this method of bonding.

The insulating spacer is positioned between the upper and lower circuits and is welded at several points. The high-frequency sound waves produce heat that causes the material to bond at selected points. However, all the switch layers must be chemically compatible and have melting temperatures within 35°F of each other.

Bond strength of a weld point is typically as high as 95% of the original materials bonded.

Like heat staking, ultrasonic welding allows potential electro-static discharge flashover to enter between the laminates at the switch assembly perimeters. Overall switch performance and E.S.D. protection are significantly improved by concealing perimeter edges with a bezel or gasket seal.

Chapter 6
Conductive Materials

This chapter discusses the characteristics of several electrical carriers used in membrane switch construction. They include:

- Silver conductives
- Carbon conductives
- Gold conductives
- Indium tin oxide conductives
- Copper conductives
- Nickel conductives
- Tin/lead conductives
- Palladium conductives
- Metal dome conductives

6.1 Silver Conductive Ink
Silver conductive ink is the preferred electrical carrier for polyester and polycarbonate membrane construction. Silver inks have many inherent advantages:

- Favorable conductivity to cost ratio
- Ease of application
- Ductility
- Resistance to flaking
- Long term reliability

6.1.1 Manufacture
Silver conductive inks are manufactured by blending fine silver particles in an epoxy binder to form a homogeneous polymer. The standard concentration of silver particles is 63%, but can be altered as cost requirements dictate. Keep in mind, however, that resistivity is inversely proportional to the silver concentration.

Inks with a 63% silver concentration have a typical sheet resistivity of .010 to .012 ohms per square mil..

6.1.2 Curing
Once deposited on the polyester or polycarbonate substrate, proper curing of the ink is critical. The process of curing the freshly deposited epoxy-base polymer involves exposing the conductive inks to dry heat at 100°C for an extended period of time.

Proper curing results in consistent resistivity, substrate adhesion, and lack of flaking even when folded. On the other hand, improperly cured inks are subject to flaking, poor ductility, and increased resistivity.

6.1.3 Resistivity
A fold endurance test developed by M.I.T. demonstrates the ductility of properly cured conductive inks. This test measures ductility as a function of circuit resistivity. A conductive circuit at 50 ohms/sq./mil. resistivity increases to only 90 ohms/sq./mil. after 200 270° folds.

Silver Conductive Material Product Characteristics

Test	Method	Units	Results
Sheet Resistivity	OHM meter	OHMS/Sq/Mil	.010-.012
Resistivity after flex crease (180° one cycle)	OHM meter 15 sec. after test	OHMS/Sq/Mil	.050
Fold (270° 200 cycles)	MIT fold endurance test 15 sec. after test	OHMS/Sq/Mil	.090
Resistivity After Thermal Shock			
Dry Heat	80°C, 10 days, 5 cycles 1/2 hour each, 3M oven	OHMS/Sq/Mil	.090
Humidity	Mil Standard 202E Method 103, Condition A—40°C/95% RH, 10 days, 5 cycles 1/2 hour each	OHMS/Sq/Mil	.09-.100
Tape Adhesion (after both tests)	3M tape No. 810	Visual	Excellent
Fingernail Scratch Resistance	Moderate pressure	Visual	Excellent
Abrasion Resistance (pencil borders)	ASTMD 3363-74		2H
Adhesion/ tape pull	3M Scotch tape No. 810	Visual	Excellent
Silver Migration	Mil Std. 202, 106D, 2 cycles/ day 22°C (68°F)-65°C (150°F), 90-95% RH, 5DC volts after 10 days	25 Mil lines equal spacing & 8 Mil lines equal spacing	No change from arcing or shorting out.
Sulphur	38 milligrams sulphur in one cubic ft. chamber 50°C, 80% RH for 10 days to create sulphur dioxide environment	OHMS/Sq/Mil	No loss in resistance: noted discoloration
Salt Spray	ASTM B117 95°F, 5% salt solution, 10 dyas	OHMS/Sq/Mil	Initial: .0118 After salt test: .08 Initial after crease: .050 After crease and salt test: .011

6.1.4 Cost Extending Silver
Should unit cost be an overriding concern, carbon or epoxy fillers may be added to silver conductive inks. This process lowers the silver concentration and thus lowers the materials cost. However, circuit performance is also lowered due to increased resistivity.

6.1.5 Silver Migration
Silver migration can be thought of as a form of leaching which causes the silver particles to separate from the epoxy polymer. Areas that have experienced migration become points of increased resistivity and potential shorting.

Silver migration is of concern when dealing with non-sealed keyboards, or keyboards with external venting.

Silver migration may occur under high humidity. This migration can be inhibited by depositing a carbon layer over the silver conductive routing. This carbon layer forms a barrier that decreases the chance of migration.

External switch components, such as termination/interface flextails, are particularly prone to silver migration due to their exposure to environmental moisture. Consequently, additional protection is strongly recommended.

Carbon overcoating of the entire circuit routing is advised for non-adhesively sealed keyboards because they are subject to environmental moisture. However, this additional manufacturing step increases unit cost. The carbon overcoating process is described in Section 6.2.3.

6.2 Carbon Conductives
Carbon conductive ink serves as an alternate electrical carrier for polyester and polycarbonate membrane construction. These inks have the advantage of reduced cost when compared to silver inks.

However, carbon conductive inks also have higher resistivity. For that reason, their use is limited to applications that can accommodate high resistance values.

6.2.1 Manufacture
Carbon conductive inks are manufactured by blending fine carbon particles in an epoxy binder to form a homogeneous polymer. Desired circuit resistivity dictates the concentration of carbon particles

Carbon ink resistivity is inversely proportional to carbon particle concentration.

6.2.2 Curing
Once deposited on the polyester or polycarbonate substrate, proper curing of the ink is critical. The process of curing the freshly deposited epoxy base polymer involves exposing the conductive inks to dry heat at 160°C for an extended period of time.

Proper curing results in consistent resistivity, substrate adhesion, and lack of flaking even when folded. On the other hand, improperly cured inks are subject to flaking, poor ductility, and increased resistivity.

6.2.3 Overcoating
Carbon inks often serve as a protective coat for exposed silver conductive ink circuitry. This carbon coating restrains silver particles from migrating out of the silver epoxy polymer, and forming an area for potential short. Silver migration prevention should be considered if the keyboard may be exposed to environmental moisture and high humidity.

Vulnerable areas that may require a carbon coating are non-adhesively sealed keyboards, circuit routing exposed through external venting, and termination/interface flextails.

Note
If migration is of concern in your application, you should strongly consider a protective carbon coating.

(Refer to Section 6.1.5 for more information about migration.)

6.2.4 Resistor Usage
In addition to other applications, carbon conductive inks are sometimes used as low cost circuit resistors. Voltage step down, or the lowering of line voltage through increased resistance, is achieved when a specific amount of carbon ink is deposited at a point in the circuit. Light Emitting Diodes (L.E.D.s) require low voltage and may now be driven directly by circuits without a separate resistor.

6.3 Gold Conductive
Gold as a conductor is the most efficient electrical carrier. Due to gold's substantially higher cost, it is primarily used when stringent environmental factors are present or high performance is desired.

Gold contact points or gold plating over silver conductives may be used in flexible membrane keyboards and nickel/gold plating in rigid PCB-backed keyboards.

Gold contact points improve switch performance by reducing contact bounce. Values as low as 1 millisecond may be achieved.

6.3.1 Gold and Silver Interface
Both gold and silver are low-resistance current carriers. However, they are not compatible, and a carbon polymer or other conductive material is recommended to chemically separate when they are used together.

The carbon polymer or other conductive material prevents silver from migrating into the gold layer which could cause the production of a non-conductive alloy at the interface of the two metals.

Although gold can be plated over silver, it is not recommended due to the added cost and questionable performance improvements. Gold/silver migration greatly accelerates after 10,000 switch closures.

6.4 Copper
Copper conductive inks serve as an alternative to silver conductive inks.

Although a good conductor, copper suffers from two serious weaknesses:

1 Copper's cost/performance ratio is not as attractive as silver. (This ratio is defined as the cost of metal versus its ability to act as an electrical carrier.)

2 Copper conductive inks are subject to continued oxidation when exposed to the environment. This factor limits their effectiveness.

Risk of oxidation can be eliminated by applying a carbon polymer coating over the copper circuitry. However, this additional manufacturing step erodes copper's initial cost advantage over silver.

Note
Etched copper printed circuit boards or flexible circuitry are manufactured using an entirely different process. They are widely accepted as conductive carriers.

6.5 Nickel
Nickel conductive ink is a low cost alternative to silver conductive inks. However, nickel has an inherently high resistance value.

Nickel has proven to be an effective electrical carrier in applications such as low cost electro-static discharge shielding where exposure to high temperature operating environments is not a factor.

In addition, nickel is less vulnerable to oxidation than copper, making it more effective when used in non-sealed keyboards.

Nickel conductive inks are epoxy polymer-based and are manufactured using the same process as silver inks. (Refer to Section 6.1.1 for more detail.)

6.6 Tin/Lead
Tin/lead plating is typically used as contact points on PCBs.

Tin/lead's conductivity and resistance value are generally acceptable for most PCB applications. In addition, oxidation is not a factor.

Contact bounce averages five milliseconds or less. Should lower contact bounce time be required, gold is the recommended plating on contact points. Refer to Section 6.3..

6.7 Palladium
Palladium, suspended in an epoxy polymer applied over silver conductives, was originally developed to prevent silver migration of conductive circuits on ceramic substrates.

However, palladium applied over silver conductives on flexible membrane circuits has proven to be unsuccessful. The high baking temperatures required to cure palladium properly are above the melting points of the polyester or polycarbonate plastic films used in membrane keyboard substrates.

Section 6.2.3 provides more information about methods for combatting silver migration.

6.8 Metal Domes
Metal dome contacts usually consist of stamped stainless steel domes.

Stainless Steel Metal Domes are typically classified as either:

Contact Type

Non-Contact Type

Within these two categories a wide variety of materials, actuation forces and sizes exist. Although the selection of the dome type is application specific and should be left to the keyboard manufacturer, it is important to note that the proper dome type, ie. contact type or non-contact type, is used with the appropriate construction technique.

Chapter 7
Circuit Design

When designing keyboard circuitry the following factors should be considered:
- Circuit encoding
- Circuit interface/termination
- Touch sensation (flat or tactile)
- Price objectives
- Material selection

By determining factors such as lead routing, key spacing, and dome height, a more precise keyboard specification can be developed. Keep in mind that the final circuit design is normally the responsibility of the manufacturer.

This chapter discusses four circuit types:
1 Flat membrane
2 Tactile membrane
3 Printed circuit board (metal domes)

7.1 Flat Membrane
Flat membrane circuits can be constructed using the following fabrication techniques:

- Single fold
- No fold

This decision depends largely on the density of the internal circuit routing. If common buss, two pole, or three pole encoding is used, the routing will be relatively dense.

You can formulate the capacity of a particular design by establishing a minimum edge to trace distance, keypad diameter, keypad spacings, openings for displays, L.E.D.s, or other keyboard electronics and interface/termination exit.

The total resistance value of a conductor may be determined by multiplying the total cross-sectional area of the conductive traces by the conductor's length. The cross-sectional area is inversely proportional to its total resistance value. In contrast, the conductor length is proportional to its resistance value.

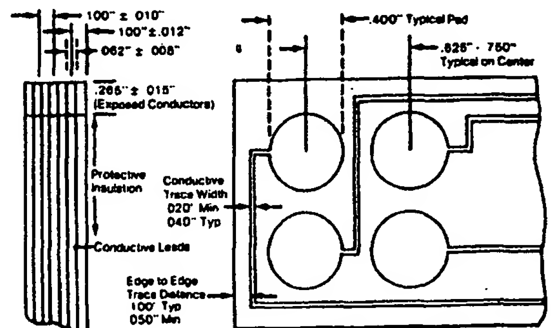
To further estimate this figure, refer to Chapter 6, which discusses conductive materials. Choose the appropriate conductive material for the application and determine its ohms per sq. resistive value. (Note that these values are typically given for a thickness of 1 mil.) Since most membrane circuit routings are 1/2 mil., double the given resistive value.

Next determine the length of the run or lead and calculate its average width. Divide the average width into the length and multiply by the resistance value. The result is the resistivity for that particular lead. Be sure to include the flextail length when making the calculation.

Conductive lead spacings on flextail interface/termination routing are typically 0.100" with standard routing widths of 0.50" to 0.62".

Note: The minimum bend radius on a flex-tail is .100". Should the application require sharp folds and/or bends, the keyboard manufacturer should be alerted to this during the design cycle to allow for the compression or expansion of the conductive materials.

Circuit Design



Flex Tail   Internal Conductives

Note Max distance of conductive trace to edge provides best Electro Static Discharge Protection

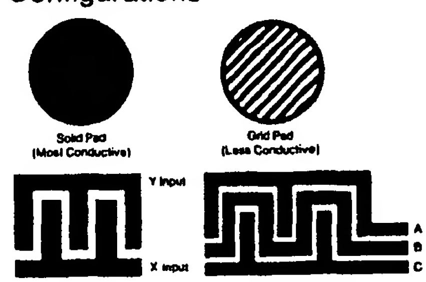
Note
The length of the flextail and the type of connector substantially affect the cost of the switch. (Further information about termination hardware can be found in Chapter 9.)

Contact pad configurations include solid, grid, and two or three finger interdigitated types. Solid contact pads are commonly used in x/y and common buss designs. Grid contact pads are designed to be used in place of solid pads; this technique conserves material and thus lowers cost.

Interdigitated pads allow for two or three inputs to appear on the same surface at specific switch locations. Interdigitated pads are used in conjunction with the following encoding techniques:

- Common buss
- Two pole
- Three pole

Pad Configurations



Protection against electro-static discharge can be increased by maintaining the maximum amount of distance between the circuit and the edge of the keyboard.

7.2 Tactile Membrane
Tactile membrane circuits can be constructed using the following fabrication techniques:

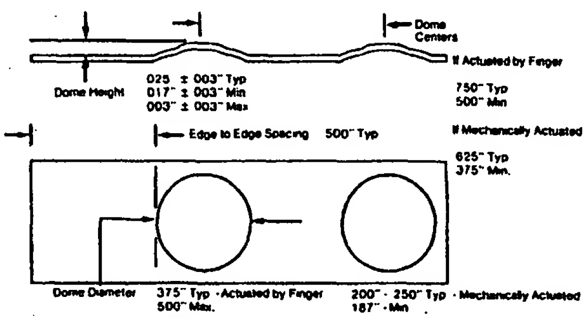
- Single fold
- No fold

This decision depends largely on the density of the internal circuit routing. If common buss, two pole, or three pole encoding is used, then the routing will be relatively dense.

As described in Section 1.2, the tactile membrane consists of a basic flat membrane with a domed upper circuit. This domed circuit provides tactile feedback and keypad location.

Tactile/Membrane

Cross-Section



Note: The minimum bend radius on a flex-tail is .100". Should the application require sharp folds and/or bends, the keyboard manufacturer should be alerted to this during the design cycle to allow for the compression or expansion of the conductive materials.

Dome height and method of actuation determine the intensity of the tactile feedback. Although actuation force is typically 8 to 12 ounces, this value can be altered to meet specific switch requirements.

Tactile membrane construction can be used with the following types of contact pads:

- Solid
- Grid
- Two or three finger interdigitated

Solid pads are often used in x/y and common buss designs. Grid contact pads are designed to be used in place of solid pads; this technique conserves material and thus lowers cost.

Interdigitated pads permit two or three inputs per switch to appear on the same surface at specific switch locations. Should run time (the time required to close multiple switches as measured by a microprocessor) or contact bounce increase unacceptably when using interdigitated pads, mechanical actuators can be used to produce a more positive depression of the membrane and switch contacts. (See Sections 1.6 - 1.9.)

Laminate acrylic adhesive bonding is recommended in all tactile membrane designs since heat staking and ultrasonic welding do not generally provide sufficient stability for the circuit.

Heat staking and ultrasonic welding both bond the keyboard layers in four to eight individual locations while laminate adhesives secure the entire surface. This bonding of the entire surface accounts for the added durability achieved with laminate acrylics.

Spacing and resistive values are outlined in Section 7.1.

7.3 Printed Circuit Board (PCB)
Printed circuit boards are typically used as the rigid lower circuit in metal dome, flat membrane, and tactile membrane keyboards. By using a rigid PCB, lower contact bounce can be achieved. In addition, the PCB provides a rigid mounting structure for the keyboard that can accommodate electronic components.

When choosing between a single or double-sided plated PCB you should consider the circuit routing density and encoding requirements

Circuit Design

Interdigitated finger pads are recommended for use on the PCB when a membrane keyboard is used. Shorting pads are typically used for the upper circuit of both flat and tactile membrane keyboards.

In metal dome/PCB construction, the printed circuit board's contact points consist of a plated perimeter conductor pad on which the "feet" of the dome sit. This perimeter pad acts as one half of the input conductor. A second plated conductive point on the PCB is located at the center of the perimeter conductor.

Contact results when pressure is applied to the dome and it flexes to a plated contact center on the PCB.

The following plating options are available for use with a copper-clad PCB:

- Tin/lead plate
- Nickel plate
- Nickel/gold plate

The choice depends upon required electrical performance, as well as cost and environmental factors.

When using a double-sided plated board, insulating solder masks can be used to protect exposed contact points.

Chapter 8
Electro-static Discharge/Radio Frequency Interference/Electro-magnetic Interference

8.1 Electro-static Discharge

Electro-static discharge or E.S.D. refers to the accumulation of static electricity on the surface of the human body. Friction between dissimilar insulating materials produces this electrical charge. For instance, walking on a rug and then touching a grounded object produces and transmits such a charge.

The usual voltage accumulation averages 10-15 KV, although it may reach as high as 50KV under ideal conditions. Low relative humidity, dissimilar materials with high friction, and large dry body surface area all result in voltage accumulation.

Effective E.S.D. protection must be built into keyboards that contain electrical impulse sensitive CMOS, MOS, and Bipolar I.C. switch components. Such components are used extensively in miniaturized intelligent and dumb controls. The need for electro-static discharge protection increases as keyboard applications move into the general marketplace where little attention is paid to discharge factors.

Protection of electronic components and keyboard assemblies against electro-static discharge can be achieved through either passive or active intervention.

Passive E.S.D. intervention consists of the successive buildup of the non-conductive layers of the upper keyboard without using independent grounding. By contrast, active E.S.D. intervention is produced by incorporating a separately grounded printed circuit between the graphic overlay and the upper circuit layer.

8.1.1 Passive E.S.D. Intervention

Passive E.S.D. intervention is recommended under two conditions:

1 The keyboard contains few sensitive electronic components.

2 Cost is a major factor.

The extent of the protection depends on several factors:

- Use of acrylic adhesive to seal the keyboard
- Type of keyboard termination
- Size and shape of the internal circuit routing
- Thickness and choice of construction material
- Presence of electronic display windows

A typical 0.015" to 0.020" thick sealed membrane keyboard provides 13-20KV "punch out" E.S.D. protection. Punch out E.S.D. is defined as the charge which passes directly through the plastic construction film and enters the internal circuit.

Each membrane layer added to the keyboard construction improves punch out resistance of the keyboard against E.S.D. entry. For these reasons, laminated acrylic adhesives of a sealed keyboard increase E.S.D. protection by a factor of 2 to 4 over heat staking or ultrasonic welding.

Electrical Dialectric Strength—
Non-Conductive Insulating Materials

Materials	Test Method	Volts/Mil
Polycarbonate	ASTM D149	1,400
Polyester	ASTM D149	3,330
High Density Polyethylene	ASTM D149	450-500
Low Density Polyethylene	ASTM D149	450-1,000
Polypropylene	ASTM D149	3,000-4,000

E.S.D. flashover is of greater concern than punch out. Flashover is defined as the charge that enters between the membrane layers at the perimeter of the keyboard or other points. These points include external venting ports, air gaps left in the laminate adhesives during manufacturing, and electronic display windows.

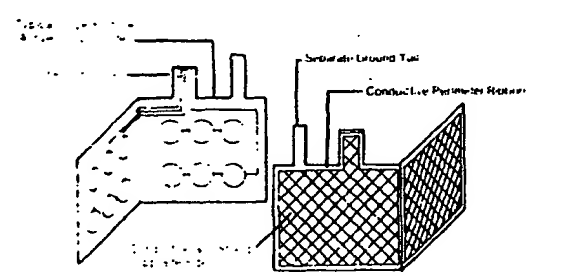
E.S.D. flashover often follows surface carbon tracks leading to perimeter entry points. These carbon tracks are formed during previous electro-static discharges. Consequently, each E.S.D. flashover lowers the keyboard's overall E.S.D. hardness. Once an E.S.D. flashover charge has penetrated the keyboard perimeter, it will enter the circuit routing generally at the closest circuit to the edge.

8.1.2 Active E.S.D. Intervention

Active E.S.D. protection consists of printing a separate electro-static shield of silver or nickel conductive inks on a non-conductive surface. This printed surface is located between the graphic overlay and upper circuit and is independently grounded so that an E.S.D. charge bypasses the vulnerable circuit components. The ground should be at earth potential or connected to either the product casing or the common side of a battery. E.S.D. protection in excess of 25KV is generally obtainable using this method.

Electro-Static Discharge Shield

Printed Conductive Grid Pattern On Folded Circuit

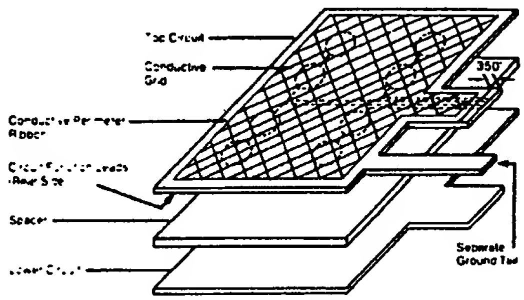


Electro-static Discharge/Radio Frequency Interference/Electro-magnetic Interference

The grounded electro-static shield significantly hardens the keyboard against either punch out or flashover damage. However, a particularly strong flashover may bypass the shield and enter the circuit routing at the perimeter. This risk can be eliminated by adding a non-conductive perimeter bezel or a conductive perimeter bezel that has been independently grounded in the same manner as the shield. (See Section 13.2.1.)

Electro-Static Discharge Shield

Printed Conductive Grid Pattern On A No Fold Circuit



8.1.3 E.S.D. Protection
E.S.D. protection should also be designed into a keyboard without the use of additional components by following these rules:

- Use acrylic laminate adhesives that add non-conductive layers and seal perimeter edges.
- Avoid air bubbles between laminates during construction.
- Locate individual switch pads prior to the circuit routing design.
- Place all circuit routing as far away from the keyboard edge as possible.
- Check the circuit routing design before finalizing the keyboard's visual design.

All of the above design considerations can be incorporated into the keyboard's construction by the manufacturer without compromising the appearance of the keyboard.

8.2 Radio Frequency Interference and Electro-Magnetic Interference
Radio Frequency Interference (RFI) and Electro-Magnetic Interference (EMI) consist of high and low frequency radio waves. Many computing devices emit such waves or are susceptible to interference from such waves including computer terminals and peripherals, as well as digital telephones. RFI emissions must be below levels prescribed by the FCC. These levels were established as of October 1983.

The following table shows the acceptable levels for Class A devices (intended for commercial, industrial, or business environments) and Class B devices (intended for general market or home use):

Specifications:
Radiated RFI is limited as follows:

Class A Computing Devices

Frequency (f) (MHz)	Distance (Meters)	Maximum Field Strength (uV/m)
30-88	30	30
68-216	30	50
216-100	30	70

Class B Computing Devices

Frequency (f) (MHz)	Distance (Meters)	Maximum Field Strength (uV/m)
30-88	3	100
88-216	3	150
216-1000	3	200

Conducted RFI is limited as follows:

	Maximum RF Line Voltage (db above 1 uV)	
Frequency (MHz)	Class A	Class B
0 45-1.6	60	48
1 6-30	69 5	48

Note Conducted limits in the frequency range of 10 to 450 KhZ are under consideration

Equipment operating in excess of 10,000 cycles per second emits a high frequency interference that can affect nearby television, radio, and communications receivers. The FCC standards of October 1983 were designed to counteract this problem.

RFI and EMI shielding of membrane keyboards is accomplished using techniques similar to those employed in combatting E.S.D. Additional layers of polycarbonate or polyester material sealed with laminate acrylic adhesives may provide sufficient RFI or EMI protection depending on the particular equipment the keyboard is connected to.

Care should be taken to provide additional protection to flexible termination/interface cables, which are a major source of RFI or EMI contamination. For low RFI or EMI emission sources, polycarbonate and polyester material extended over the flextail may be sufficient. When RFI or EMI emissions are strong, a variety of copper, thin metal, or steel mesh shielded flexible cables are available.

Additional internal RFI or EMI shielding of the keyboard itself is accomplished by incorporating a silver or nickel screen-printed conductive layer between the graphic overlay and the upper circuit. This conductive grid is manufactured by the same process as an E.S.D. shield and is independently grounded.

External shielding is accomplished by completely surrounding the keyboard and accompanying electronics with copper, aluminum, or stainless steel plates to ensure complete RFI or EMI containment.

Chapter 9
Interface and Termination

When selecting a method of connecting the keyboard to electronic components, the following factors should be considered:

- Cost
- Reliability
- Performance
- Design
- Environment
- Anticipated insertions and extractions

Mechanical specifications for most interface terminations are standard. Consequently, circuit construction techniques can be designed for compatibility with specific types of interface termination methods. The no fold circuit, for instance, consists of two flextails facing in opposite directions. As a result, only certain types of interface terminations are possible.

9.1 Exposed Conductors

In this method the keyboard is supplied with a flextail of specific length, which has exposed traces on its surface. The flextails can be either insulated or non-insulated up to the point of termination, depending on the requirements of the application.

Four connector types are commonly employed in this method:

1 AMP-Trio mate
2 AMP connector clip
3 Molex flat connectors
4 Precision Concepts flat connectors

These interface products serve as the receptacle portion of the termination and are mounted to a printed circuit board.

9.1.1 AMP-Trio Mate

The AMP-Trio mate is a low insertion, high extraction connector that can be used in either parallel or perpendicular PCB mounting. It accommodates up to 22 positions on a single connector.

The contacts are tin-plated phosphor bronze and are housed in a self-extinguishing terminal.

The contact design of the AMP-Trio mate permits it to accommodate all types of circuit flextails (i.e., exposed conductive material on separate flextails in opposing directions).

This connector system allows for opposing exposed conductors on a flex tail to make a gas tight connection of moderate costs.

AMP Trio-Mate Connector Specifications

Environmental Characteristics

Thermal Shock— −55°C and +85°C for conductive ink

Temperature/Humidity Cycling—10 temperature humidity cycles between 25° and 65°C at 95% RH

Industrial Gas—96 hours of 200 ppb each of nitrogen dioxide, sulfure dioxide and hydrogen sulfide

Electrical Characteristics

Dielectric Withstanding Voltage—1.5 kvac dielectric withstanding voltage, one minute hold

Insulation Resistance—5000 megohms min., initial

Capacitance—1.0 picofarads max.

Mechanical Characteristics

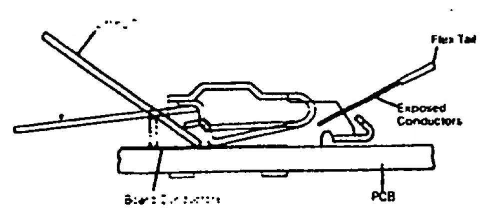
Vibration—10-55-10 Hz traversed in 1 min. at .06 [1.52] total excursion

Physical Shock—100 G s sawtooth in 6 milliseconds

9.1.2 AMP Connector Clip

The AMP connector clip holds the exposed conductors of a flextail in contact with the plated contacts on a printed circuit board. As such, it performs no electrical function.

Amp Connector Clip



The AMP connector clip can accommodate up to 13 positions. However, the design of this interface requires that all the exposed contacts of the flextail be on one side, generally limiting its use to single and two fold circuit designs. (Refer to Chapter 2.)

This connector system is the lowest cost type available.

AMP Connector Clip

Environmental Specifications

Thermal Shock—MIL-STD-1344, Method 1003.1; ten cycles between the extremes of −20°C and +105°C

Thermal Aging—MIL-STD-1344, Method 1005.1; 96 hrs. of continuous exposure at +85°C

Industrial Gas—10% SO_2 atmosphere for 24 hrs.

Humidity—MIL-STD-1344, Method 1002.2; 240 hrs. of temperature cycling and high humidity

Vibration—MIL-STD-1344, Method 2005.1; 12 hrs. of sinusoidal vibration between the frequency limits of 10 to 2000 hz at 20G acceleration

9.1.3 Molex 7583-CN

The Molex 7583-CN connector series is a non-gas-tight, low or high pressure contact system. It is available for either right angle or perpendicular PCB mounting.

The Molex 7583-CN can accommodate from 5 to 21 positions on a single connector. The contacts are tin-plated phosphor bronze and are housed in a self-extinguishing terminal.

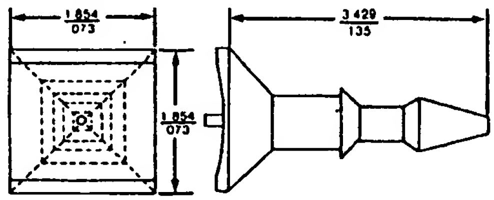
The design of this interface requires that all the exposed contacts of the flextail be on one side, generally limiting its use to single and two fold circuit designs. (Refer to Chapter 2.)

This connector system provides a locking method to hold the flextail in place is the connector at moderate costs.

Polarizing Key
A polarizing key is an option commonly used to plug an unused contact on a female terminal connector. This partially plugged terminal can now be connected in only one way.

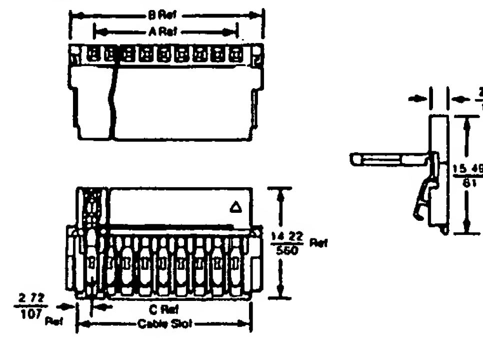
Polarizing Key

Fits in Contact



9.2 Single Row/Crimp Type
Single row/crimp connectors provide a gas-tight termination interface between a flextail and connector. In this method the keyboard is supplied with a flextail of specific length. Crimped to the flextail(s) is a male or female shrouded connector.

Single Row Berg



This connector is attached by inserting the flextail into a V-shaped opening that consists of a complex beryllium copper crimping contact. Once inserted, the opening is mechanically crimped to the flextail, forming an electrical contact and a gas-tight connection.

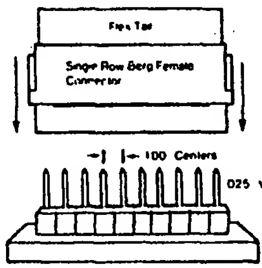
Crimping pierces through both sides of the flextail, allowing any of the circuit designs discussed in Chapter 2 to be used.

The cost of this interface depends on its contact plating material (tin/lead or gold) and the number of pins required.

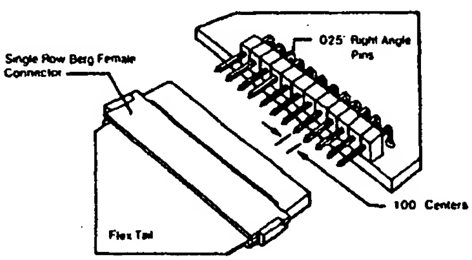
The Berg Clincher 65801 is the most commonly used connector of this type and is available in either receptacle or pin type construction.

Both designs require that a separate interface device be soldered in place on the PCB. This interface device receives the clincher.

Berg Single Row Connector



Berg Single Row Connector



This connector system allows for a gas tight, shrouded connector attached directly to the flextail at moderate costs.

9.2.1 Berg Single Row

Physical Characteristics

Housing:
Material
Polypropylene, flame retardant per UL 94 V-0

Color: Blue

Contact:
Body Material:
1/2 Hd. Cupro-Nickel Alloy, UNS-C 72500

Body Plating:
2.54μm (100μ") min. thick 60/40 Tin-Lead
or
0.76μm (30μ") Gold plating in contact area

Spring Material:
1/2 Hd. heat-treated Beryllium Copper Alloy, UNS-C 17200

Spring Plating:
0.25μm (10μ") min. thick 60/40 Tin-Lead
or
0.51μm (20μ") min. thick Gold

Number of Positions	Part Numbers Tin-Lead	Part Numbers Gold
2	65801-002	6580[illegible]
3	65801-003	6580[illegible]
4	**65801-004**	**658[illegible]**
5	65801-005	6580[illegible]
6	**65801-006**	**658[illegible]**
7	**65801-007**	6580[illegible]
8	**65801-008**	**65801-[illegible]**
9	**65801-009**	**65801-[illegible]**
10	**65801-010**	**65801-[illegible]**
11	**65801-011**	**65801-[illegible]**
12	**65801-012**	**65801-041**
13	**65801-013**	**65801-042**
14	**65801-014**	**65801-043**
15	**65801-015**	**65801-044**
16	**65801-016**	**65801-045**
17	**65801-017**	65801-046
18	**65801-018**	**65801-047**
19	65801-019	65801-048
20	**65801-020**	**65801-049**
21	65801-021	65801-050
22	65801-022	65801-051
23	65801-023	65801-052
24	65801-024	65801-053
25	65801-025	65801-054
26	65801-026	65801-055
27	65801-027	65801-056
28	65801-028	65801-057
29	65801-029	65801-058
30	65801-030	65801-059
31	65801-031	65801-060
32	65801-032	65801-061

Standard parts in boldface.

Performance Data

Electrical
Insulation resistance:
$\geq 5 \times 10^4$ megohms min. between contacts

Dielectric withstanding voltage:
500 volts AC. rms, 60 Hz at sea level

Current rating:
2 amps max. terminated to 610 grams/meter², 1.57mm (2 oz./ft², 0.062") wide copper cable laminated between 0.08mm (0.003") thick polyester insulation material

Mechanical
Insertion force:
500 grams per contact when mated to 0.64mm (0.025") square tin-lead plated pins

Average insertion force:
400 grams per contact when mated to 0.64mm (0.025") square tin-lead plated pins

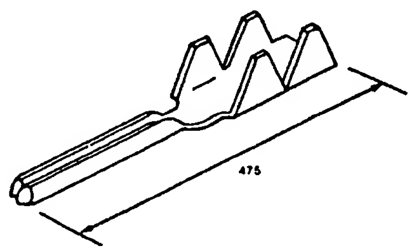
Minimum withdrawal force:
30 grams per contact when unmated from 0.64mm (0.025") square tin-lead plated pins

Average withdrawal force:
50 grams per contact when unmated from 0.64mm (0.025") square tin-lead plated pins

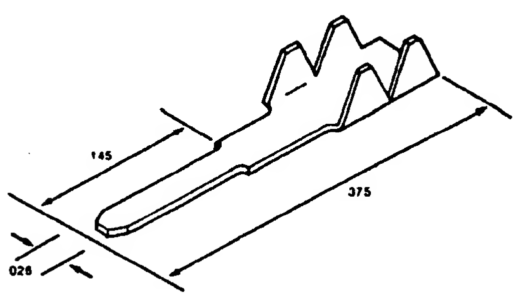
9.3 Pin Contacts and Solder Tabs
Pin contacts and solder tabs offer a gas-tight termination between flextail and contacts.

In this method the keyboard is supplied with a flextail of specific length. Crimped to the flextail(s) is a non-shrouded connector of either individual pins or solder tabs.

Pin Contact

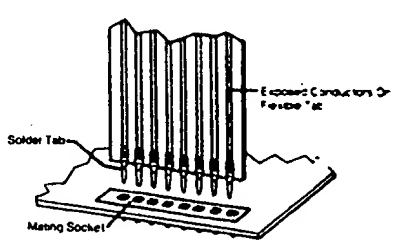


Solder Tab



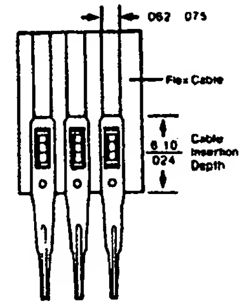
After the pin contacts are crimped, they are inserted into receptacle sockets that have been soldered to the contact points of the printed circuit board.

Solder Tabs



Crimping pierces through both sides of the flextail, allowing any of the circuit designs discussed in Chapter 2 to be used.

Berg Solder Tab

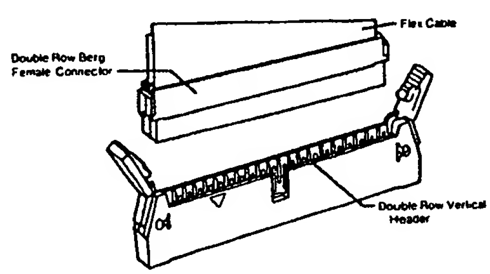


The cost of this interface depends on the contact plating material (tin/lead or gold) and number of positions required.

9.4 Double Row Connectors
Double row connectors are mainly used when the number of flextail leads exceeds the space required for a single straight row connector type.

When used with a membrane keyboard, double row connectors require that the keyboard have two separate flextails, one above the other. These flextails must crimp a single straight row connector on each tail. The Berg Clincher 65801 is the most commonly used connector for this application. These two connectors then fit into a single double row header that has been soldered to the printed circuit board.

Berg Double Row Connector



Keyboards that use a printed circuit board as the lower circuit can accommodate a double row pin connector soldered directly into the keyboard.

The cost of this interface depends on the contact plating material and number of positions required.

Many companies manufacture double connectors and most of them work to standard specifications.

Chapter 10
Non-Conductive Substrate Materials

Non-conductive material can be used either as the electrical circuit substrate or as a separate dielectric layer. This chapter discusses several types of non-conductive insulating carriers:

- Polycarbonate
- Polyester
- Glass epoxy
- Polypropylene
- High-temperature plastic

Each of these materials has its advantages and the selection should be based on the requirements of the intended application.

10.1 Polycarbonate as a Substrate Material
Polycarbonate film serves as an effective non-conductive substrate, particularly as manufacturers identify and correct some of its previous shortcomings.

A non-conductive substrate must remain dimensionally stable during manufacturing and actual use to ensure uninterrupted circuit routing. Under both dry and humid conditions, shrinkage rates of polycarbonate at 75°C to 175°C are less than one percent. Moreover, exposure to dry heat at 125°C for six months indicated no increase in brittleness or cracking.

In addition, it remains malleable (i.e., does not crack) when folded, minimizing the risk of damage to the printed conductor inside a 180° folded membrane circuit. (Refer to the fold test described in Section 11.1.7.) Polycarbonate film in association with recommended conductive inks has excellent adhesion qualities.

Tests were conducted with 5 mil. polycarbonate film where the circuit routing had been printed with DuPont 5007 silver ink. The film was then folded and pressed with a 15 pound bar. Circuit resistivity increased only 12% at room temperature and an additional 3% when the folded circuit was heat sealed for four or five seconds at 350°F. (Refer to Section 11.1 for further discussion of polycarbonate dimensional stability.)

An important consideration of a material's dielectric strength is its ability to withstand electro-static discharge that could otherwise damage internal electronic components. Building up successive layers of polycarbonate material in membrane keyboard construction can result in passive E.S.D. protection of 20KV or more. (Refer to Section 8.1.)

The dielectric strength of four mil. polycarbonate film is 1400 volts/mil. at 25°C and volume resistivity of 1×10^{16} ohms/centimeters at 25°C. The dielectric constant of polycarbonate film does not change from −25°C to 142°C.

Polycarbonate film is easily processed and die cut, yet its tensile yield strength is 8,400-8,800 psi (ASTM D882 with 4 mil.) and its tear strength is 1,150 to 1,570 psi (ASTM-49T with 4 mil.).

Polycarbonate's overall tensile modulus averages 290,000 psi at 25°C.

Note
Tensile modulus is an expression of the ratio between a deforming force and the corresponding fractional deformation caused by the force.

No outgassing of polycarbonate film has been reported following tests conducted at 1×10^7 mm Hg at 100°C.

Polycarbonate has a recommended list of conductive inks that have been approved for material compatibility.

Non-Conductive Substrate Materials

10.2 Polyester as a Substrate Material
Polyester possesses many characteristics which make it an ideal non-conductive substrate:

- Resistance to abrasion and chemicals
- Reasonable dimensional stability
- High tensile modulus

Because of these qualities, polyester has gained a broad acceptance among membrane keyboard manufacturers as a conductive routing substrate.

As described in Section 1.1 and 1.2, the upper circuit of a membrane keyboard flexes through openings cut in the spacer layer in order to make contact with the lower circuit. The total travel of the upper circuit is typically 0.008" for non-tactile and .028" for tactile. With a tensile modulus of 500,000 psi at 25°C, polyester ensures in excess of ten million operations.

The dimensional stability of polyester depends on temperature. Thermal shrinkage of a five mil. polyester film at 100°C is approximately 0.5%, which is acceptable for most applications. Thermal shrinkage increases to approximately 2% at 175°C.

Although generally acceptable, this additional shrinkage can become critical if the graphic overlay is polycarbonate while the underlying circuit layers are polyester. Under certain conditions, the polyester layer can shrink out of register, impeding switch actuation with the polycarbonate touch panel. This potential problem may be dealt with when initially designing the keyboard by providing a sufficient margin in keypad location on the graphic overlay.

The resistance of polyester to abrasion and chemical damage is excellent. (Refer to Section 11.1 for more information.)

The dielectric properties of polyester are also outstanding. The breakdown voltage from an electro-static discharge of five mil. is 18,500 volts at 60 Hz or 2,700 volts/mil. at 23°C.

Building up successive layers of polyester material in membrane keyboard construction can result in passive E.S.D. protection of 20KV or more.

No outgassing of polyester film has been reported following tests conducted at 1×10^7 mm Hg at 100°C.

Like polycarbonate, polyester has a recommended list of conductive inks that have been approved for material compatibility.

10.3 Glass Epoxy
Glass epoxy non-conductive substrates are used as the base for the construction of printed circuit boards. The PCB is used as a rigid lower circuit for membrane and metal dome keyboard construction. The thickness is typically 0.032", 0.062", or 0.093".

PCBs conductive routing is generally copper deposited through electrolysis and then tin/lead reflow plated. The circuit routing is typically on both sides of the PCB, simplifying the layout and concentration of the routing. Additional daughter boards and PCBs may be stacked together for more complex circuitry and electronics. Gold through hole plating of contact points is an optional conductor for keyboards that require high performance or operate in a harsh environment.

The standard glass epoxy material is F.R.4 rated (fire retardent #4 specification).

Should any additional electronics require assembly to the PCB during keyboard manufacture, a solder mask may be specified that coats and protects the exposed circuitry from damage during assembly.

10.4 Polypropylene
Polypropylene is primarily used in switch technology as a dielectric insulator. Common applications involve the placement of two to three mil. films over the top circuit layer of a flexible membrane switch as a conductive dielectric insulator.

Polypropylene has the following properties:

Volt resistivity ohms/cm: 1×10^{19}
Tensile modulus rating: 240,000 psi
Leading strength: 3,000-4,000 volts/mil.

Chapter 11 Graphic Overlay Materials

As the outermost layer of a membrane keyboard, the appearance of a graphic overlay is primarily responsible for the operator's overall impression of the keyboard.

Functionally, the graphic overlay identifies keypad location, accommodates a logo, and provides window display zones for status information about the equipment.

Currently, polyester and polycarbonate plastic films are the preferred graphic overlay materials. Film selection depends on the specific requirements of the application.

11.1 Polycarbonate as a Graphic Material

A variety of companies manufacture polycarbonate plastic films. The largest supplier is currently General Electric Company, which markets their product under the tradename Lexan. These films have several advantages:

- Optical clarity
- Dimensional stability when heated
- Malleability

In addition, they may be used with a wide variety of recommended printing inks.

These advantages are offset by the fact that polycarbonate film offers only moderate resistance to abrasion and chemicals. Although this weakness can be minimized by adding surface hardcoats, this step often equals the cost of the polycarbonate material itself. (Refer to Hardcoat Characteristics Chart.)

Polycarbonate Film

Product Availability:

Type	Thickness
Gloss	.003"-.030"
Matte	.005"-.030"
Fine Velvet Texture	.005"-.020"
Medium Coarse Suede Texture	.010"-.020"
Hardcoat One Side	.010"-.030"

Benefits:

Haze Free Clarity
Allow true colors.

Heat Resistance
Permits high temperature applications up to 270°F in close proximity to illuminating sources

Cold Resistance
Ductile below − 40°F

Chemical Resistance
Good only to non-aromatic chemicals

Dimensional Stability
Maintained at elevated temperatures

Toughness
High tear strength

Surfaces
Different textures are available

Scratch Resistance:

Suede Excellent
Velvet Very Good
Gloss Fair to Poor
Matte Fair to Poor
Hardcoat Excellent

11.1.1 Surface Textures

Lexan can be manufactured with several surface textures:

- Gloss
- Matte
- Fine velvet
- Medium suede
- Coarse suede

The fine velvet and suedes offer superior abrasion resistance and may not require added hardcoating.

11.1.2 Embossing

Polycarbonate material reacts well to embossing due to its deformation stability at the elevated temperatures required to emboss. Polycarbonate also demonstrates exceptional ability to hold a formed shape (Refer to Section 13.1.)

11.1.3 Chemical Resistance

Polycarbonate resists a variety of dilute acid solutions, most foods (e.g., fruit juice, tea, coffee), as well as normal cleaning agents.

However, polycarbonate films without a hardcoat are moderately attacked by chlorinated and aromatic hydrocarbons, such as benzene, toluene, ketones, and esters. If the anticipated environment contains such chemicals, either additional surface hardcoating or a polyester graphic overlay is recommended. The following tables contain specific information about polycarbonate chemical resistance.

Chemical Resistance Chart

Polycarbonate (Non-Hardcoat)
Exposure: Immersed 6 days
N = No Effect S = Soluble A = Chemically Attacked

Chemical	Effect	Chemical	Effect
Bacon Fat	N (80°C)	Methyl Salicylate	S
Beer	N	Milk	N
Catsup	N	Mustard	N
Citric Acid 5%	N	Oleic Acid	N (80°C)
Cocoa	N (80°C)	Orange Juice	N
Cod Liver Oil	N	Permanent Ink	N
Coffee	N	Pine Oil	N
Grape Juice	N	Sardine Oil	N (80°C)
Iodine	N	Shortening	N (80°C)
Isopropanol 70%	N	Tea	N (80°C)
Kerosene	N	Tomato Juice	N
Lemon Juice	N	Vicks' Vaporub	N
Mayonnaise	N	Wine	N
Merthiolate	N	Wine Vinegar	N
		Whiskey	N

Exposure. Immersed one month

Chemical	Effect	Chemical	Effect
Acetic Acid. 5%	N	Light Lube Oil	N (80°C)
Detergent		Soap Solution, 5%	N
Solution. 2%	N	Oleo	N (80°C)
Freon 22 (Bomb)	S	Ozone, 1%	A
Hydrogen		Soya Oil	N (80°C)
Peroxide. 30%	N		

Note:
Amines, alkalies and ammonia will attach polycarbonate film as well as chlorinated hydrocarbons, aromatic hydrocarbons and ketones. Polycarbonate offers very good solvent resistance to oil, alcohol and aliphatic hydrocarbons. Chemical resistant coating is available.

Hardcoat Characteristics Chart
Chemical and abrasion resistant surface

Optical

Property	Test Method	Units	Typical Value
Light Transmission	ASTM D1003	%	≥ 90
Haze	ASTM D1003	%	≤ 0.7
Gloss	ASTM D523		
60° Backpainted, Flat Black			95
60° Unpainted, Clear			160
85° Backpainted, Flat Black			80
85° Unpainted, Clear			90

Abrasion

Property	Test Method	Unit	Typical Value
Taber Abrasion	ASTM D1044	Change	
500 gram load		in %	
CS-10F wheel		haze	
10 cycles			+1.2
25 cycles			+1.3
50 cycles			+2.0
100 cycles			+6.3
300 cycles			+14.3

Chemical Resistance

Solvents	Test Method	Effect on Coating
Heptane	1 hour	None
Ethyl, Isopropyl alcohol	continuous	None
Dichloromethane	"wet" contact	Partially dissolved
Carbon tetrachloride	@72°F	None
Acetone, Methyl ethyl ketone		None
Butyl Cellosolve		None
n-Butyl acetate		Slightly pitted
Toluene		Slightly pitted
40% Sodium hydroxide		None
Conc. Hydrochloric acid		None
Amoco diesel fuel		None
Amoco unleaded premium		None
Gunk S-C degreaser		None
Turpentine		None
VM & P naphtha		None

11.1.4 Optical Clarity

The optical clarity of polycarbonate surpasses that of polyester.
Lexan 1.2 mil. clear film has light transmission values of 91% with 0% haze at wavelengths from 400 mu to 1,000 mu. Due to its non-crystaline molecular structure, as polycarbonate film thickness increases to 10 mil., its light transmission decreases to 90% while haze, or image blurring, increases to just 0.5%.

This distortion-free quality allows for use of subsurface color printing onto the graphic overlay without risk of color or image distortion.

Polycarbonate transparent membranes have an anti-glare hardcoat which is also mar and chemical resistant. (Refer to Section 11.1.8.)

11.1.5 Tensile Strength

Polycarbonate film is easily processed and die cut, yet its tensile yield strength is 8,400-8,800 psi (ASTM D882 with 4 mil.) and its tear strength is 1,150 to 1,520 psi (ASTM-49T with 4 mil.). (Refer to Polycarbonate Film Properties Chart.)

Polycarbonate's overall tensile modulus averages 290,000 psi at 25°C.

Note
Tensile modulus is an expression of the ratio between a deforming force per unit area and the corresponding fractional deformation caused by the force.

Graphic Overlay Materials

Polycarbonate Film Properties

Physical Properties

ASTM Method	Property	Units	Value
D1505	Specific Gravity		1.20
D774-46	Bursting strength	Mullen Pts.	25–35
D643-43	Folding Endurance		Survives 250–400 Folds
D570	Water absorption	%	.35
D882, 638	Tensile yield strength		
	F(°C)	psi	
	77 (25)		8400–8800
	167 (75)		7000
	257 (125)		4500
D882, 638	Tensile Modulus		
	77 (25)		290,000–300,000
	167 (75)		270,000
	257 (125)		215,000
D882, 638	Ultimate tensile strength		
	77 (25)		8,600–9,300
D882, 638	Elongation	%	
	77 (25)		85–105
	257 (125)		120
D1004-49T	Tear strength initiation	lb/in	1150–1520
D1922 (Elmendorf)	Tear strength propogation	lb/in	44–55

Thermal Properties

ASTM Method	Property	Units	Value
D648	Flexural deflection at		
	264 psi	°F (°C)	275 (135)
	66 psi		285 (140)
D1637	Tensile heat distortion at		
	50 psi	°F (°C)	302 (150)
D696	Coefficient of linear expansion between:		
	−30°C and 30°C	in/in/°C	6.75×10^{-5}
	−22°F and 86°F	in/in1/2°F	3.75×10^{-5}
D759	Resistance to cold	°F (°C)	−150(−101)
C351	Specific heat	Btu/lb °F	.30
D746	Brittleness temperature	°F (°C)	−211(−135)
	Flammability (UL Bulletin 94) 20 MIL		V-2

Electrical Properties

ASTM Method	Property	Units	Value
D150	Dielectic constant (4mil) (−13° to 288°F)		
	60Hz		2.99
	10^3		2.99
	10^6		2.93
	Power Factor (4 mil)		
	60H	%	0.10–0.23
	10^3		0.13
	10^6		1.10
D149	Dielectic strength (4 mil)	Volts/mil	
	77°F (water)		1400
	122°F (oil)		1830
	212°F (oil)		1835
D257	Volume Resistivity	Ohm-cm	10^{16}

11.1.6 Thermal Shrinkage

Unlike polyester, polycarbonate is malleable and yet demonstrates little functional deformation due to temperature.

Thermal shrinkage at 175°C is less than 1%. In addition, exposure to dry heat at 125°C for six months indicated no increase in brittleness or cracking.

This lack of shrinkage is noteworthy since many manufacturing techniques require elevated temperatures. Once the material returns to room temperature, irregularities and shrinkage must be kept to a minimum. Flame retardant polycarbonate is also available. (Refer to Section 11.1.9)

11.1.7 Fold Testing

Polycarbonate film exceeds a 180° fold test of 400 cycles (ASTM D643-43), an important consideration in membrane folded circuits. Most keyboard designs are specified for a minimum of one million to a maximum of ten million operations. (An operation consists of one switch closing and then opening.) Both polycarbonate and polyester meet this requirement.

Graphic Overlay Materials

Abrasion Resistance (Reported as a percent of transmitted light scattered, i.e. haze.)

Taber Abrasion Test ASTM D-1044	%	%
500 Gram Weight		
Start	2.0	2.0
10 cycles	2.2	7.5
25 cycles	2.5	16.3
50 cycles	2.63	18.5
75 cycles	4.75	18.7
100 cycles	4.96	21.5

Chemical Resistance ASTM D-1308 (Time until visual attack)

10% Sodium Hydroxide	>36 hrs.	>16 hrs.
40% Sulfuric Acid	>36 hrs.	< 8 hrs.
Gasoline	>36 hrs.	>16 hrs.
Benzene	>36 hrs.	<60 sec.
Acetone	>36 hrs.	<60 sec.
Methylene Chloride	>36 hrs.	< 8 hrs.
Ethylene Dichloride	>36 hrs.	>16 hrs.
Carbon Tetrachloride	>36 hrs.	>16 hrs.
Methyl Alcohol	>36 hrs.	>16 hrs.

11.1.9 Flame Retardant Polycarbonate

In an application where fire prevention is of great concern or in an extremely hostile environment, a flame retardant polycarbonate may be specified which is UL listed for flammability. The following chart illustrates the properties of this film.

Description:
Flame-retardant polycarbonate film, available from .015" to .030" thick, UL rated 94V-0.

Properties

Optical

Property	Test Method	Units	Typical Value
Light transmission	ASTM D1003	%	85
% Haze	ASTM D1003	%	1

Mechanical

Property	Test Method	Units	Typical Value
Specific gravity	ASTM D792		1.32
Water absorption	ASTM D570	%	0.28
Tensile strength			
Yield	ASTM D882	psi	10,000
Break	ASTM D882	psi	8,800
Elongation	ASTM D882	%	25-50
Tensile Modulus	ASTM D882	psi	320,000
Tear Strength			
Initiation	ASTM D1004	lb/in	1700-2000
Propagation	ASTM D1922	lb/in	73-82(.015" film)
Impact Strength	Gardner	in.—lb	60(.030" film)

Thermal

Property	Test Method	Units	Typical Value
Tensile Heat Distortion @50 psi	ASTM D1637	°F (°C)	302 (150)
Flexural Deflection @264 psi	ASTM D648	°F (°C)	275 (135)

Electrical

Property	Test Method	Units	Typical Value
Dielectric Strength	ASTM D149	volts/mil	1520(.015" film)
Dielectric Constant	ASTM D150		
60 Hz			2.9
10^3 Hz			2.8
10^6 Hz			2.8
Dissipation Factor	ASTM D150	%	
60 Hz			0.26
10^3 Hz			0.28
10^6 Hz			1.17
Volume Resistivity	ASTM D257	ohm-cm	10^{16}

Flammability

Property	Test Method	Units	Typical Value
UL Flammability	Bulletin 94		V-0 @ .015"
Oxygen Index	ASTM D2863	%	33
Horizontal Burn	ASTM D635		
AEB		in	1.4
ATB		sec	5
FAA Flammability	FAR 25.853		pass
Smoke Density	ASTM E662/	D(4 min)	6
(Flaming)	NFPA 258	D(max)	36

Chemical Resistance

Household Liquids	Test Method	Effect on Coating
Strong Tea	24 hours	None
Black Coffee	@ 80°F,	None
Catsup	80% R.H.	None
Mustard		None
Vegetable dye		None
Vinegar		None
Lemon juice		None
Tomato juice		None
Grape juice		None
Milk		None
CLOROX™		None
WISK™		None
FANTASTIC™		None

Other Properties

Property	Test Method	Units	Typical Value
Tensile Strength	ASTM D882	psi	
Yield			9,400
Break			10,200
Elongation	ASTM D882	%	85–105
Tear Strength	ASTM D1922	lb/in	44-55
Resistance to humidity	GE Test (720 hrs. @ 100°F, 100% RH)	—	No blistering No visual change
Heat Aging	GE Test (168 hrs. @ 160°F)	—	No blistering No visual change

Graphic Overlay Materials

11.2 Polyester as a Graphic Material

A variety of companies manufacture polyester plastic films. The largest supplier is currently E.I. DuPont DeNemours & Company, which markets their product under the tradename Mylar. These films have several advantages:

- Cost
- Durability
- Resistance to abrasion

However, polyester lacks the optical clarity at thicknesses frequently required in graphic overlays.

11.2.1 Surface Textures

Mylar can be manufactured in either gloss or matte light-reflective textures. Unlike polycarbonate, standard textures are not available except by photo-active U.V. texturing. This process requires pretreatment of the polyester material and adds an additional cost to the final product.

11.2.2 Embossing

Polyester does not react well to embossing or thermoforming because significant dimensional instability begins to appear at the high temperatures required to emboss. (At temperatures above 160°C, polyester is subject to shrinkage and warping and melts at 250°C.) Polyester may be embossed using male/female hard tooling. This additional tooling does add to the cost of the product.

11.2.3 Optical Clarity

Unlike polycarbonate, polyester has a crystalline molecular structure. This structure ensures durability, but interferes with optical clarity by diffusing light as it passes through the material.

A typical graphic overlay thickness of 7.5 mil. demonstrates transmission levels of 85% and a 1.5% haze. These values indicate a somewhat weak image definition and color rendition. Ten mil. polyester proves unacceptable as a graphic overlay due to increased haze and poor light transmission.

11.2.4 Tensile Strength

Polyester's overall tensile modulus averages 500,000 psi at 25°C.

Note
Tensile modulus is an expression of the ratio between a deforming force per unit area and the corresponding fractional deformation caused by the force.

A 1 mil. film exceeds the ASTM-MIT fold endurance test by compiling over 100,000 180° cycles. However, polyester does demonstrate increased current resistivity in a folded circuit.

The dimensional stability of polyester depends on temperature. Thermal shrinkage of a five mil. polyester film at 100°C is approximately 0.5%, which is acceptable for most applications. Thermal shrinkage increases to approximately 2% at 175°C.

11.2.5 Chemical Resistance

As noted by its exceptional tensile modulus, polyester shows unusual durability. Its major advantage over polycarbonate is its superior resistance to chemicals, particularly hydrocarbon-based chemicals. (Refer to Polyester Chemical Resistance Chart.)

Polyester Chemical Resistance

Chemical	Effect
Alcohol	N
Cooked Beets	N
Liquid Bleach	N
Cooked Carrots	N
Catsup	N
Cherries (liquid maraschino)	N
China Marker	S*
Cocoa	N
Coffee	N
Cola	N
Cranberry Sauce	N
Crayon	S**
Detergent (50% solution)	N
Dishwashing Liquid	N
Ethyl Acetate	N
Ferric Chloride	N
Grape Juice	N
Hand Lotion	N
Iodine	N
Lemon Juice	N
Lighter Fluid	N
Machine Oil	N
Maple Syrup	N
Mayonnaise	N
Mercurochrome	N
Merthiolate	N
Milk	N
Mustard	N
Nail Polish	S**
Nail Polish Remover	N
Oleomargarine	N
Orange Juice	N
Pencil	S***
Rubber Cement	N
Cooked Spinach	N
Tea	N
Tomato Juice	N
Food Color	S****
Vegetable Oil	N
Vinegar	N
Worcestershire Sauce	N

16 hours at room temperature, then washed with water.

N = No Effect
S = Stain
* - No stain after washed with alcohol
** - No stain after washed with nail polish remover
*** - Slight mark after washed with soap and water
**** - Slight mark after washed with nail polish remover

11.2.6 Durability

Polyester's crystaline structure gives the material superior abrasion resistance when compared to polycarbonate. Most keyboard designs are specified for a minimum of one million to a maximum of ten million operations. (An operation consists of one switch closing and then opening.) Both polycarbonate and polyester meet this requirement.

Polyester Film

Physical and Thermal Properties

Physical Properties at 23°C and 50% RH

Property	Typical Value 1 mil film	Unit Measure	Test Method
Ultimate Tensile Strength (MD)	25,000	psi	ASTM D882-64T
Stress to produce 5% Elongation	15,000	psi	Method A (100% elongation
Ultimate Elongation (MD)	120	%	per minute)
Tensile Modulus (MD)	550,000	psi	
Impact Strength	6.0	kg-cm/mil	DuPont Pneumatic Impact Tester
Folding Endurance	100,000	cycles	ASTM D2176-63T (1 kg loading)
Tear Strength—propagating (Elmendorf)	20	grams/mil	ASTM D1922-61T
Tear Strength—initial (Graves)	800	grams/mil	ASTM D1004-66
Tear Strength—initial (Graves)	1,800	lbs./inch	ASTM D1004-66
Bursting Strength	66	psi	ASTM D774-63T
Density	1.395	grams/cc	ASTM D1505-63T
Coefficient of Friction—Kinetic (film-to-film)	.45	—	ASTM D1894-63
Deformation Under Load	0.11	%	ASTM D621-64 Method A 500 lb. load

Thermal			
Melting Point	250°C		Fisher-Johns
Zero Strength Temp.	248°C		DuPont Test*
**Penetration Temp.	230°C;270°C		ASTM D876-65
Coefficient of Thermal Expansion (30°C-50°C)	1.7×10^{-5}	inch/inch/°C	Modified ASTM D696-44
Coefficient of Thermal Conductivity (1000 "Mylar" A at 25 to 75°C)	1.05	(BTU)(inch)/(ft²)(hr)(°F)	
	3.7×10^{-4}	(cal)(cm)/(cm²)(sec)(°C)	
Specific Heat (25°C)	.28	cal/gm/°C	
Heat Sealability	No		
Flammability	Slow to self extinguishing		

*The temperature at which a single sheet of film over a ½" diameter heated rod supports a tensile load of 20 psi for 5 seconds.
**1000gm. weight on $\frac{1}{16}$" dia. ball. 0.5°C/min. rise rate; second value at 35°C/min. rise rate.

11.3 Selective Texturing

The surface coating or texturing of selected areas of a polyester or polycarbonate graphic overlay is rapidly gaining popularity. Surface texturing can enhance a graphic overlay in several respects:

- Protect the overlay from a variety of chemicals
- Harden the overlay against abrasion
- Reduce glare from window and display zones
- Define functional areas on the overlay

These considerations are of particular importance when selecting a polycarbonate material for a keyboard that may be subjected to a harsh environment. Chemical resistance to solutions of 5% hydrochloric acid and aromatic hydrocarbons may be obtained with selected photo-active U.V. surface coating.

Polyester and polycarbonate can be textured in four general degrees of coarseness: gloss, matte, velvet, and suede.

Polyester is normally resistant to abrasion and chemicals without U.V. surface texturing. It requires pretreatment if it is to be surface textured. For these reasons, it is less often surface textured.

Selective texturing involves screen printing a photosensitive compound over the surface of the graphic overlay where texturing is desired. Areas such as window display zones which are to remain untextured should not be coated. The coated overlay is then passed through a curing chamber of nitrogen gas and high intensity ultra-violet light. The final qualities of the coating depend on the concentration of nitrogen gas, the intensity of the ultra-violet light, and the length of exposure to the ultra-violet light.

Selective texturing can also be used for individual key identifications by applying a texture to either the keypads or the backgrounds.

Chapter 12
Color Matching Systems

The colored inks that are printed on the graphic overlay must be carefully selected and manufactured. In particular, you should note the ambient light source when specifying color to the keyboard manufacturer.

Basically, there are three types of light sources:

1 Daylight
2 Incandescent light
3 Flourescent light

Since all the graphic printing takes place on the sub-surface or rear side of the exposed surface of the graphic overlay, you must also consider the gloss level desired on the front of the overlay. You can specify this level as a quantitative value, or in terms of matte, low luster, or high gloss.

This chapter briefly discusses four color matching systems:

1 Pantone Matching System
2 Federal Standard Series 595
3 Munsel
4 Customer-supplied color chips

12.1 Pantone Matching System
The Pantone Matching System, sometimes abbreviated to P.M.S., is the most commonly used means of color matching.

This system evolved from the offset printing trade and, consequently, the color swatches represent the appearance of the colors on paper, not sub-surface printing on plastic.

When specifying a high-gloss level refer to the C section of the color wheel; for matte or low-luster gloss, use the U section.

Note
Due to their production process, the color wheels sometimes vary from book to book.

12.2 Federal Standard Series 595
This series represents an improvement in consistency, opacity, and gloss levels over P.M.S.

An enamel-baked process is used to produce the color chips in this series, lending them their high consistency and opacity.

In contrast to the two levels of P.M.S., the Federal Standard Series consists of three levels of gloss rating:

1 Gloss
2 Low luster
3 Lusterless

This color matching system was designed for use by the spray paint finishing industry. For this reason, the Federal Standard Series should be selected when matching graphic keyboard colors to sprayed housing finishes.

12.3 Munsel
Unlike other color systems, the Munsel system does not equate color to any fixed formula of paint or ink pigmentation. Rather, it plots color on a three-dimensional scale.

The coordinance scale which the colors are based on is known as the Hunter L.A.B. Scale. It has become the standard for high-quality color definition.

A coordinance plot is calculated for specific colors by assigning a numeric value for the chroma, hue, and intensity. Because these values are quantifiable, the system can utilize computers to aid in analysis.

12.4 Customer-Supplied Color Chips
Occasionally, a keyboard manufacturer is requested to match the overlay colors to a set of customer-supplied chips. These chips are typically either standard corporate color chips or a color that appears on equipment which will be in proximity to the keyboard.

As mentioned at the opening of this chapter, you should supply the manufacturer with the ambient light source, surface textures, and gloss levels

12.5 Spectrometer Measurement
Computer-aided analysis provides the best method of ensuring consistent color matching.

A customer first selects a color from one of the color matching systems or provides a color chip. A computer-aided photospectrometer then determines a quantitative value of the customer-selected color That selected color now becomes the "standard" against which the keyboard manufacturer prepares the graphic ink pigments.

These ink pigments are then combined and the resultant ink is test printed and analyzed by the photospectrometer. The determined values of the test run printing and the customer-specified color are compared on a three-dimensional graph for accuracy. This comparison also considers ambient light, graphic overlay material and gloss levels. Using the Hunter L.A.B. scale as a constant, a value of 0.4 ($\pm$0.2) at all coordinance points is considered a match. Any color difference of 0.4 or less compared to the customer standard is undetectable to the naked eye.

Chapter 13
Key Identification

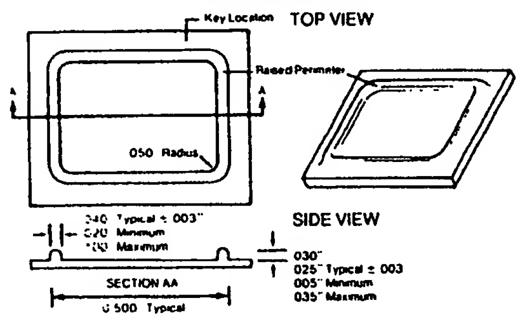
In addition to the use of graphics and color, there are three methods for identifying keypad location on a graphic overlay:

1 Embossing
2 Bezels
3 Selective texture

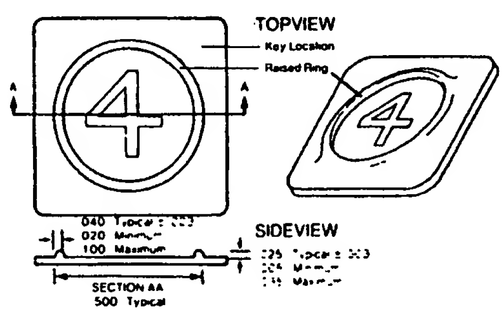
13.1 Embossing
Embossing proves to be a versatile technique since a variety of configurations can be created, including raised circles, squares, or rectangles. In addition, no danger of dirt buildup exists since the embossing is formed from the graphic overlay and not by adding separate layers with cut outs at keypads over the graphic.

For flat non-tactile membrane keyboards, an embossed raised perimeter or ring key-pad boarder can be added to provide positive keypad location.

Embossed Raised Perimeter Rectangular Key

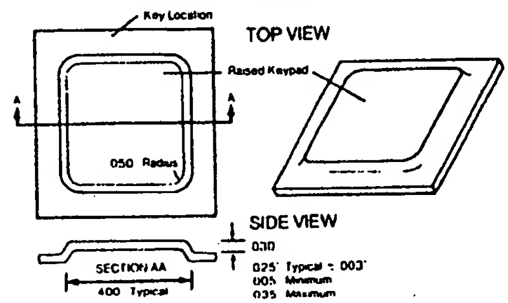


Embossed Raised Perimeter Ring Keypad



For tactile membrane and tactile metal dome/PCB keyboards without an acutator layer, each keypad on the graphic overlay is embossed in a raised configuration to protect the upper circuit from surface tension caused by the graphic overlay which may preload and partially close the underlying switch.

Embossed Raised Square Key



The embossing process itself involves using a heated match mold tool to raise a keypad or border on a graphic overlay. The maximum height is 0.035" above the overlay surface.

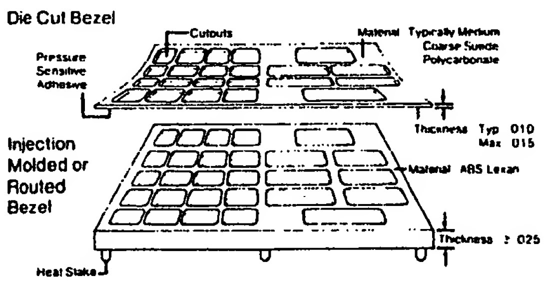
Note
A matched male/female die increases the tooling cost.

When using embossing to accent a key location, it is important to specify the detail of the embossing design. Although both polycarbonate and polyester can be embossed, polycarbonate forms more readily and requires less expensive tooling than polyester. These advantages are due to its lower thermal forming temperature.

13.2 Bezels
Keyboard bezels typically take one of two forms:
1 Surface Bezel
2 Perimeter bezel

13.2.1 Surface Bezels
A surface bezel consists typically of a 10 mil. polyester or polycarbonate film with die cut openings at each keypad location. In this way, the surface bezel provides a means of tactile location for the keypads. Additionaly, the feel of the surface bezel can be enhanced by texturing.

Bezel Types



A surface bezel can also be an injection-molded or routed frame with openings at keypad locations. An injection-molded surface bezel would require more expensive tooling than a die-cut film surface bezel.

Note
A surface bezel increases the risk of dirt becoming trapped at the edges of the keypads.

13.2.2 Perimeter Bezels
Although perimeter bezels do not typically define key location they may be used to secure and define functional areas on a keyboard. The perimeter bezel consists of an injection-molded plastic frame which mounts around the outer edge of the keyboard. The bezel seals the otherwise exposed edges of the keyboard's laminated layers from peeling, dust, and chemical spills. In addition, it allows for easy one piece surface mounting of the entire keyboard assembly.

Enhanced protection from electro-static discharge is also provided by a perimeter bezel in two ways:

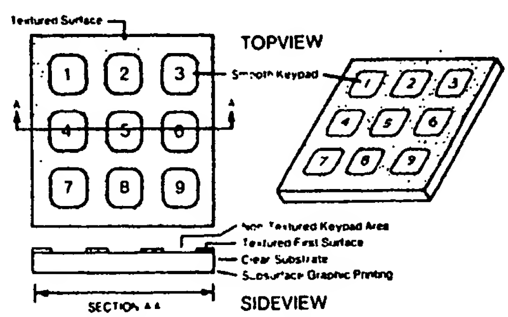
1 Passive E.S.D. protection by use of a non-conductive injection-molded bezel which mechanically seals the exposed edges of the keyboard to points of entry from E.S.D. flashover.

2 Active E.S.D. protection by the use of a conductive, independently grounded perimeter bezel which effectively bypasses the internal circuitry. (Refer to Section 8.2.)

A perimeter bezel is usually heat staked to the keyboard.

13.3 Surface Texturing
Surface texturing of the graphic overlay material can be used to identify a keypad or group of keys which perform similar functions. This texturing involves the use of a photosensitive coating and ultra-violet light. (The process is described in Section 11.3.)

Selective Texture Keys



Note
Surface texturing of a graphic overlay does not interrupt the overlay surface. Dirt does not become trapped at the keypad edges.

Chapter 14
Keytops and Actuators

14.1 Keytops and Actuators

Floating or hinge keytops can be assembled over a tactile membrane switch or over a metal dome switch. Choice of dome type depends on cost, life expectancy, and touch requirements. An actuator tip must be designed as an integral part of the key. The actuator is always applied to the center of the dome.

14.1.1 Metal Dome Actuators

All metal dome constructions require a pointed actuator with a rounded bottom that corresponds to a depression on the center of the metal dome itself. This actuator would be designed on both a separate or hinged key. Refer to Section 1.5.

14.1.2 Tactile Membrane Actuators

For tactile membrane switches, the actuator can have two distinct shapes. For living hinge keytop designs, the actuator is D-shaped with a flat bottom. For separate floating keytops, the actuator is round with a flat bottom. Refer to Section 1.8.

14.1.3 Keytop Design

Keytops can be standard or custom low profile designs with texture or sculpture. Height of the keytop depends upon customer requirements.

For full travel membrane keyboards, the keytop is commonly specified to meet DIN standards for ergonomic design.

14.1.4 Floating Keytops

Floating plastic keys are assembled over membrane or metal dome switches. The keys are stationed in place by means of a bezel or frame positioned over the switch layer. In the keytop design, the actuator must be integral to the key itself. Refer to Section 1.6.

14.1.5 Living Hinge Keytop

Living hinge keytops consist of a single frame of keys with actuators that mount over a switch layer. The keytops are attached to the frame by a thin plastic tab that acts as a hinge, allowing the key to flex.

The shape of the actuator, which is an integral part of the keytop, depends upon whether a tactile membrane or metal dome switch is specified. Dome choice depends on tooling cost, travel, force, feel, and life expectancy requirements. Refer to Section 1.8

Chapter 15
Display Zones

This chapter discusses three construction techniques used when incorporating a window display zone on the keyboard:

- Dyed-inset window filters
- Screen-printed window filters
- Dyed-underlaminate window filters

15.1 Dyed-Inset Window Filter

A dyed-inset window filter enhances the apparent brightness of electronic displays such as seven-segment displays.

The dyed-inset window filter allows the majority of those light wavelengths emitted by the display to pass through the filter while filtering out ambient light wavelengths, thus increasing the display's apparent brightness and contrast.

15.1.1 Manufacturing Process

The filter is produced by dying a clear plastic film (typically polycarbonate) to within close values of the spectrophotometric and transmission curve of the electronic display.

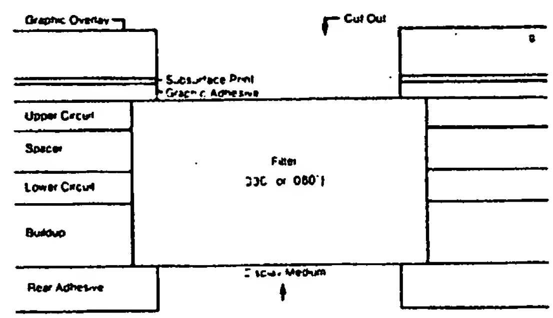
Note

This process tends to hold closer tolerances than screen-printed filters.

15.1.2 Materials

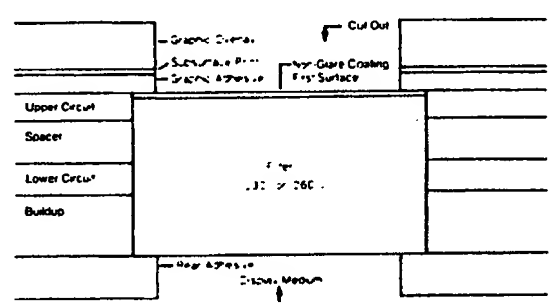
The filter window typically consists of a precision-dyed 0.030" to 0.060" rigid plastic that is mounted beneath a cutout in the graphic overlay.

Inset Window Filter



The electronic display is located on the inner surface or behind a cutout on a rigid PCB. Corresponding cutouts in the switch and build-up layers allow the electronic display to be viewed from the front of the keyboard. Use of laminated acrylic adhesives throughout the keyboard construction is recommended to ensure an environmentally sealed design. In addition, a non-glare, chemical and abrasion resistant coating can be applied over the entire exposed window surface for added protection.

Non-Glare Inset Window Filter



Note

A proper inset window filter design can withstand a high-pressure water test without compromising switch performance.

High-strength adhesives must be used in these cases.

15.1.3 Specification Considerations

The total available circuit routing area of the keyboard affects the window filter specification. Early in the design process, you must ensure that circuitry and window filter locations will not interfere with each other. Although electronic displays are frequently located at the corners of a keyboard, the accompanying window filter cutouts must not force circuit routing too close to the perimeter. (Sections 3.1, 3.2, and 8.1 discuss this topic.)

Display Zones

For product specifications refer to the following chart:

Inset Display Window Filter

Product Specifications

Property	Test	Test Method	Results
Resolution	Viewing backlighted U.S.A.F. resolving power test target with distance of 1.5" (38mm)	F.A.A. E-2481	Will resolve not less than 28 line pairs/mm.
Specular Reflection	Measurement of front surface specular reflection	Reflectometer Spectrophotometer	1.0%
Gloss	Degree of matte surface finish measured with Gardner Laboratory 60° glossmeter	ASTM-D523	54+ 6 gloss units standard
Scratch Resistant	100 gm weight applied to Gardner Laboratory Stylus SC-1620A and drawn across surface	Princeton Scratch Tester	No evidence of scratching
Hardcoat Adhesion	3M Scotchtape 810 pressed and with-drawn from surface	Tape Test	No marks on surface
Thermal	−60°F (−55°C) to 200°F (94°C) Continuous	Accelerated Weathering Tester	No change
Flammability	94V-2	U.L.	No change

Chemical Resistance	Staining Agent		Effect
	Alcohols	Agent on surface for 24 hrs., then cleaned	None
	Ball Point		None
	Caustic Soda		None
	Chlorinated Safety Solvent		None
	Coca-Cola		None
	Coffee		None
	Grease Pencil		None
	Lead Pencil		None
	Lipstick		None
	Lysol		None
	Naphtha		None
	Nail Polish		None
	Rubber Cement		None
	Soap and Water		None
	Tea		None
	Stamping Ink		None

Cleaning Agents: Filter surface can be cleaned with Windex, mild detergents, ammonia and water and propanol alcohol.

For colors and applications refer to the following chart:

Standard Inset Display Window Filters

Colors and Applications

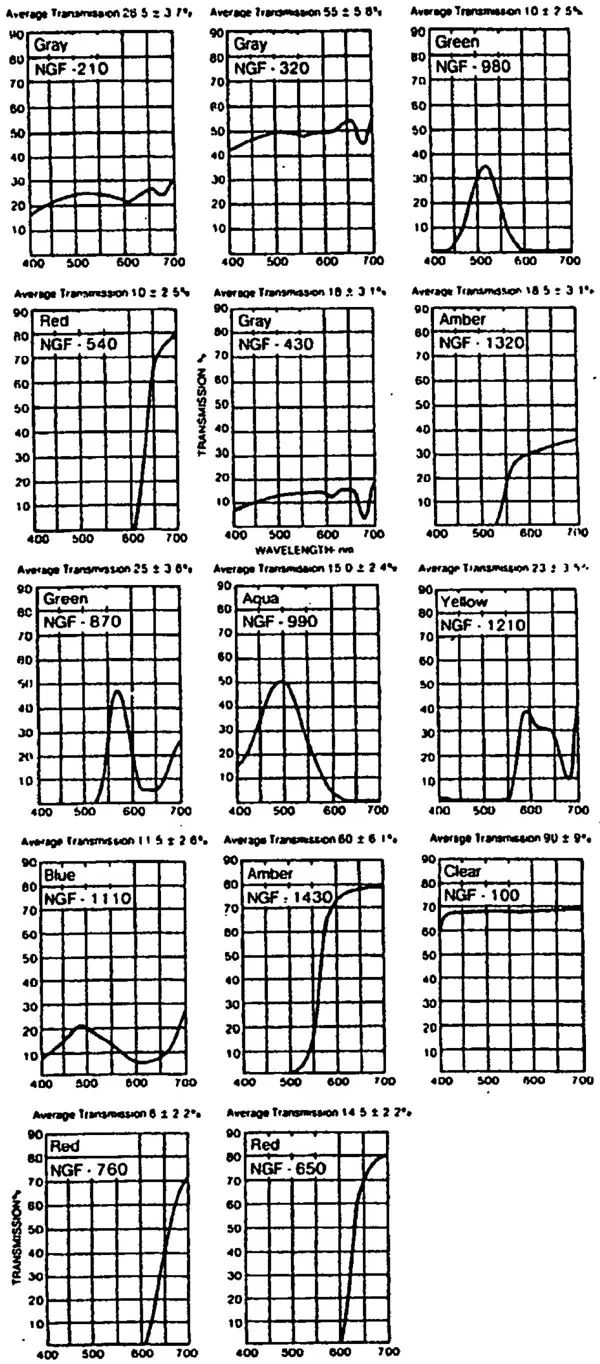
Colors	Material and Thickness	Applications
Clear, NGF-100	Polycarbonate .030", .060"	Excellent with Liquid Crystal
Gray, Medium NGF-210	Polycarbonate .030", .060"	Good with all LED display types. Excellent with white phosphors CRT. Good with vacuum fluorescent, plasma/gas discharge and incandescent
Gray, Very Light NGF-320	Polycarbonate .060"	Excellent with Liquid Crystal
Gray, Very Dark NGF-430	Polycarbonate .030"	Excellent with yellow LED display, vacuum fluorescent and incandescent. Good with plasma/gas discharge
Red, Ruby NGF-540	Polycarbonate .030", .060"	Excellent with red LED display
Red, Scarlet NGF-650	Polycarbonate .030", .060"	Excellent with orange-red LED display and plasma/gas discharge
Red, Dark NGF-760	*Rigid Vinyl .030", .060"	Excellent with incandescent and red LED display
Green, Light NGF-870	*Acrylic .060"	Excellent with green LED displays
Green, Medium NGF-980	*Rigid Vinyl .030"	Excellent with vacuum fluorescent and green phosphors CRT
Aqua NGF-990	Acrylic .060"	Excellent with vacuum fluorescent
Blue NGF-1110	Polycarbonate .030"	Excellent with vacuum fluorescent
Yellow NGF-1210	Acrylic .060"	Excellent with yellow LED display
Amber, Dark NGF-1320	Rigid Vinyl .030"	Excellent with incandescent
Amber, Medium NGF-1430	Polycarbonate .030"	Excellent with plasma/gas discharge

**Thermal Properties and Flammability Ratings are different from those of polycarbonate. Rigid vinyl withstands temperatures between −40°F (−40°C) to 125°F (54°C) with a U.L. flammability rating of 94V-0. Acrylic withstands temperatures between −40°F (−40°C) and 150°F (65°C). Flammability is 94 HB per U.L.*

Display Zones

For standard color filters with spectral and transmission values refer to the following chart:

Spectral Curves
Average Transmission for Standard Materials



15.2 Screen-Printed Window Filters

Sreen-printed window filters provide a cost effective alternative to dyed filters. Screened filters not only require less assembiy, they enable the surface of the graphic overlay to consist of a continuous, uninterrupted surface. This ensures that dirt buildup will be kept to a minimum.

15.2.1 Manufacturing Process

In the past, screen-printed window filters have suffered from the uneven appearance of the ink pigment. With the advent of new screen-printing techniques and higher pigment concentrations. this criticism is no longer a major concern.

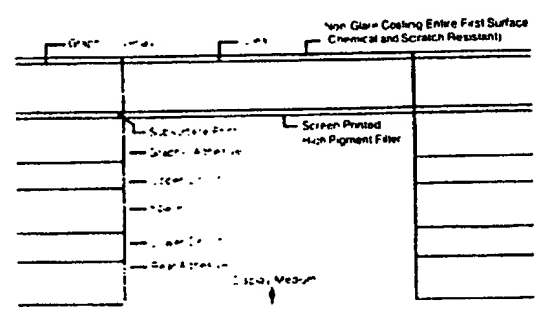
The inner sub-surface of the polyester or polycarbonate graphic overlay is screen printed in the intended window area with high-pigment filter ink. By matching the ink to the spectrophotometric value and transmission curve constant of the electronic display. those light wavelengths mainly emitted by the display are allowed to freely pass through the filter while other wavelengths are blocked. This enhances the apparent brightness and contrast of the display.

Note

Screen-printed spectrophotometric tolerances are less exact than those of dyed filters

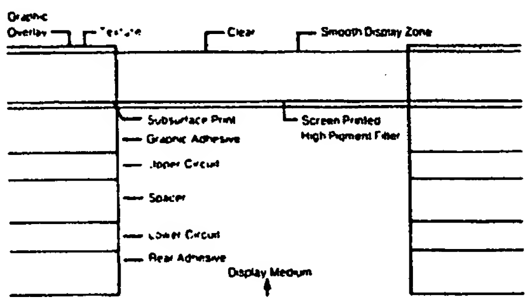
A dark graphic overlay background is advised in order to avoid any bleeding of the window filter ink with the graphic overlay ink.

Non-Glare Screen Printed Display Window Filter



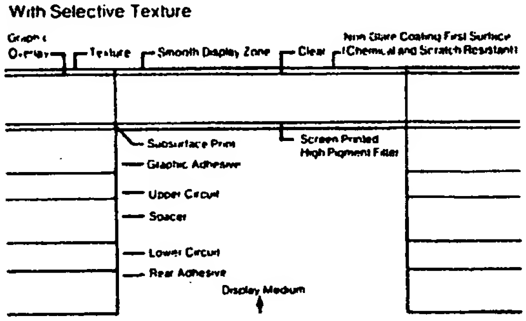
A U.V. photosensitive surface texturing can be applied to the face of the graphic overlay to define keyboard areas while the window filter area remains untextured for maximum clarity.

Screen Printed Display Window Filter with Selective Texture



Finally, a non-glare, chemical and abrasion resistant coating can be applied over the entire exposed surface, enhancing the visual aspect of the display.

Non-Glare Screen Printed Display Window Filter With Selective Texture



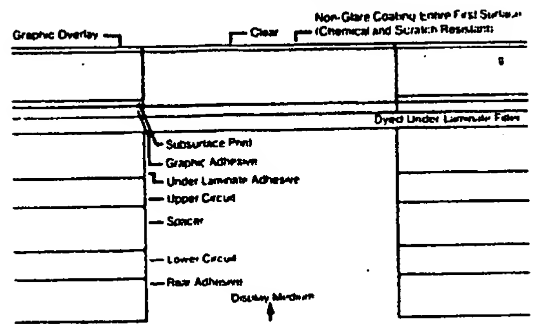
15.3 Dyed-Underlaminate Window Filters
Dyed-underlaminate window filters offer the advantages of a continuous first surface graphic and the high-quality spectrophotometric values of dyed filter material.

15.3.1 Manufacturing Process
The window display area remains clear of any graphic background printing during the standard sub-surface printing of the graphic overlay. A dyed polycarbonate film that is typically 0.005" thick is then laminated to the subsurface of the overlay with acrylic adhesives.

Finally, the filter and graphic overlay assembly is mounted over the switch layers and the electronic display. This one-piece construction greatly reduces manufacturing time and materials when compared to an inset window filter construction.

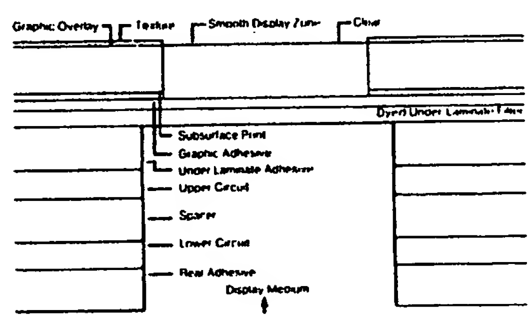
The dyed filter holds the close spectrophotometric values mentioned in Section 15.1.1.

Non-Glare Under Laminate Display Window Filter



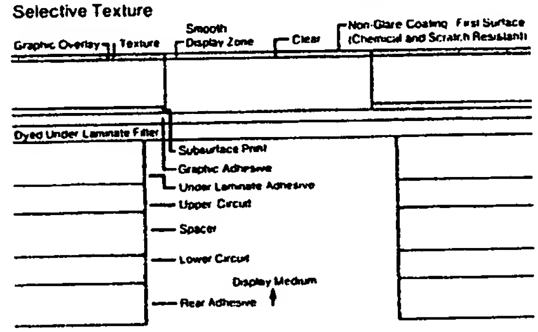
A U.V. photosensitive surface texturing can be applied to the face of the graphic overlay to define keyboard areas while the window filter area remains untextured for maximum clarity.

Under Laminate Display Window Filter with Selective Texture



As with the other filters, a non-glare, chemical and abrasion resistant coating can be applied over the entire exposed surface.

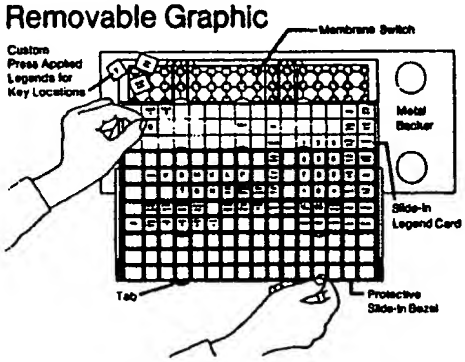
Non-Glare Under Laminate Display Window Filter with Selective Texture



Chapter 16
Removable and Interchangeable Graphics

Removable graphics are defined as a technique that permits the user to remove the entire graphic area of the keyboard. Once removed, the graphic layer can then be replaced by another graphic. This design is particularly useful when the product requires the flexibility of multiple key definitions, such as on a point of sale terminal.

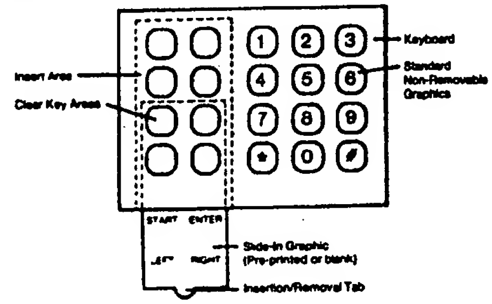
Removable Graphic



Interchangeable graphics resemble removable graphics except that the user can only change predefined sections of the graphic overlay. If, for instance, a keyboard contained a number of basic function keys complemented by several application-specific keys, then it may be desirable to enable the customer to change the graphics relating only to the application-specific keys.

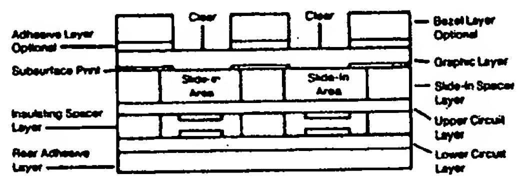
Interchangeable Graphics

Top View



Interchangeable Graphics

Cross-Section



Removable and interchangeable graphics require adequate space between keys to allow for easy overlay replacement. As a general rule, the minimum area needed between keys is .220".

Both membrane and tactile metal dome keyboards can accommodate this feature.

Because this design demands customizing, it is advisable to contact the keyboard manufacturer as early in the specification phase as possible.

Chapter 17
Backlighting

Membrane technology makes use of many forms of backlighting:

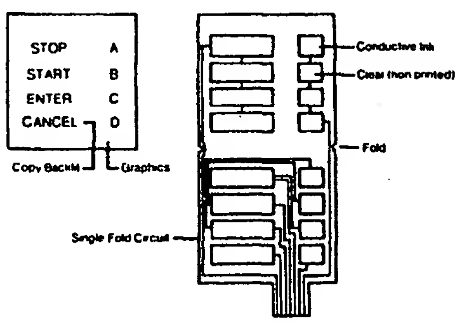
- Non-functional illumination of graphics
- Fully illuminated flat and tactile keys
- Integrated displays that combine illumination with function

When designing a keyboard, you can ensure the alignment of illumination devices by combining switching and illumination functions into a single assembly.

If your application requires backlighting, you should inform the keyboard manufacturer early in the design process.

17.1 Subtractive Circuitry
Subtractive circuitry consists of screen-printing a selective conductive pattern on both the upper and lower circuits. This selective pattern is deposited to areas within the keypad which will not be illuminated from behind. The areas of desired illumination are left clear and non-conductive.

Subtractive Circuitry/Flat



This process can be applied to both flat and tactile membrane products, permitting graphic illumination within the keypad areas.

17.1.1 Design Guidelines
Assuming that the average keypad is .500", the following guidelines apply:

1 The non-conductive clear area must be within a radius of .06–.09" of the center of the switch.

2 The graphic overlay over the non-conductive clear keypad area can be illuminated from behind the keyboard.

3 As much conductive pad area as possible should be included in the design. Additional pad area can be achieved by printing conductive ink in areas surrounding the graphics to be illuminated.

4 When subtractive circuitry is used, encoding is generally limited to x/y matrix and common buss.

5 A conductive routing path to the circuit pad is required. The minimum lead width is typically .020".

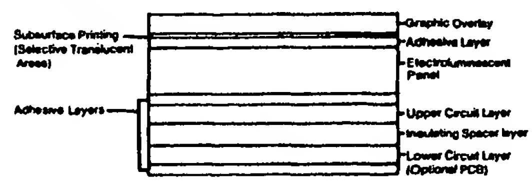
17.2 Electroluminescence
Should more than 40% of a keypad require backlighting, thin film electroluminescent panels may be an alternative.

An EL panel consists of a thin phosphorescent polycrystalline material and an aluminum rear electrode. When an electrical current is applied, illumination points appear.

Light out levels are from 15 to 200 foot/lamberts. The light display is currently monochromatic.

EL flexible panels can be manufactured to vary in size.

Electroluminescent Micro-Motion Flat Membrane
Cross-Section



17.3 Incandescent Lamps
Low-voltage incandescent lamps can be used to backlight graphic copy or functional keys.

17.3.1 Manufacture
When intended for backlighting graphic copy, the incandenscent lamp(s) is commonly incorporated into a rigid plastic backer unit, which is a customized product that requires either routing or injection molding. The translucent plastic backer acts as a light pipe, diffusing the illumination over the surface of the plastic. The membrane keyboard is then adhered to this plastic backer.

The graphic overlay and/or circuitry is designed so that illumination projects through the desired areas.

17.3.2 Selectively-Illuminated Copy
Selectively-illuminated copy within individual keypads can be produced by using the subtractive circuitry discussed in Section 17.1.

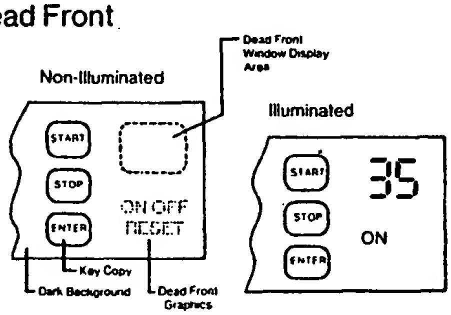
The keyboard is then bonded to the surface of a plastic light-pipe backer as described earlier in Section 17.3.1.

17.4 Dead Front
The term "dead front" refers to a process in which areas of illumination in a graphic display are rendered undetectable until they are illuminated. This can include such things as L.E.D.s, display devices, incandescent lamps, or backlit graphics.

This effect is achieved by applying a transparent black or darkly colored ink over the area to be concealed, using a screen-printing process. The surrounding area of the keyboard should be as dark as the ink to be effective.

In areas such as display zones, a second transparent color can be added behind the dead front to enhance the brightness of the display. Chapter 15 discusses display zones.

Dead Front



Chapter 18
Electronic
Component Assembly

Electronic components can often be incorporated into membrane keyboard designs. This approach offers many inherent advantages:

- Designing components into the switch assembly ensures alignment of devices such as L.E.D.s and seven segment displays with the graphic overlay portion of the keyboard.
- Assembling components at the keyboard level is more economical than adding electronics on a second PCB.
- Receiving a module, that is a fully tested and functional keyboard with electrical components, eliminates the need for individual component testing by the assembler.

The design of a keyboard module should also consider maintenance. In particular, it must be easy for individual components to be removed and serviced as required.

18.1 Light Emitting Diodes

Light emitting diodes, or L.E.D.s, verify data entry or process operation of many keyboards. There are three commonly used L.E.D.s:

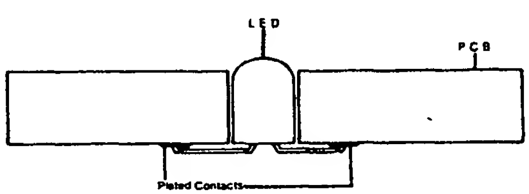
1 Lamp type
2 Bar display
3 Seven segment display

This section discusses the lamp type, which is frequently included in keyboard construction.

18.1.1 Rear Mounting

Except for transparent technology keyboards, the lower switch layer consists of either a flexible membrane or rigid printed circuit board. With rear assembly of L.E.D.s, a slight protrusion of the L.E.D. from the rear surface is unavoidable, regardless of the lower switch type.

Rear Surface Mounted L.E.D. on Printed Circuit Board



A solder connection positions the L.E.D. at the rear of the PCB. This connection can take two forms:

1 A direct solder joint to the PCB
2 A receptacle socket soldered to the PCB

The second alternative has the advantage that the L.E.D. can be easily inserted and removed since it simply inserts into the socket.

When a flexible membrane lower circuit is used, the L.E.D. assembly requires solderless conductive epoxies and adhesives. Field replacements of L.E.D.s that have been assembled in such a manner are difficult. Consequently, the keyboard manufacturer is usually responsible for such replacements. (Refer to Section 18.4 on conductive epoxies.)

The following L.E.D.s have a lamp profile that is well-suited for rear assembly:

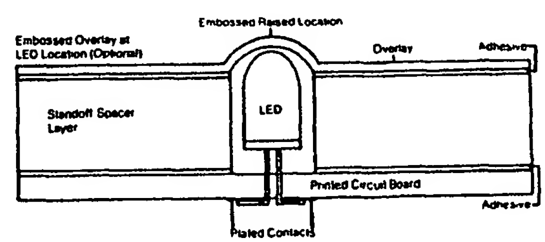
- Hewlett Packard HLMP-6300-RED
- Hewlett Packard HLMP-6400-YELLOW
- Hewlett Packard HLMP-6500-GREEN

18.1.2 Top Mounting

Lamp type L.E.D.s can also be integrated into the keyboard assembly. Both rigid printed circuit boards and flexible design circuits can be used with this approach.

Top mounting requires the addition of a spacer or standoff layer above the upper circuit. This layer compensates for the lamp profile and ensures that the graphic overlay maintains a uniform first surface.

Top Surface Mounted L.E.D. on Printed Circuit Board



The standoff layer requires either routing or injection molding.

The actual attachment of the L.E.D.s involves the same procedure as rear mounting.

18.2 Numeric, Character, and Light-Emitting Displays
Displays help verify, select, and monitor functions controlled by the keyboard. There are three commonly-used displays:

1 Seven segment L.E.D.s
2 L.E.D. light bars
3 Liquid crystal (L.C.D.)

Display components require a high density of output lines and, consequently, a rigid PCB is recommended as the lower circuit.

Like L.E.D.s, display components can be assembled on either the top or rear side of the lower circuit layer. This selection depends on the profile of the specific component and the amount of available space behind the keyboard.

18.2.1 Rear Assembly
Display components are typically mounted on a secondary PCB, referred to as a daughter board. This daughter board interfaces to the lower circuit using either a simple mechanical connection or an electrical solder connection. This choice depends on the density of both the display and keyboard outputs.

The design of such a keyboard should ensure that individual components can be easily removed and maintained.

18.2.2 Surface Assembly
Top surface mounting of displays offers the advantage of creating a protective package that minimizes potential damage in shipment and handling.

The display components are soldered to the top side of the lower circuit layer. A spacer or standoff is then added to the lower circuit. This layer compensates for the profile of the components and ensures that the graphic overlay maintains a uniform surface.

The standoff layer requires either routing or injection molding.

When designing a keyboard that uses top surface mounting, the electrical density of both the switch functions and the display outputs should be carefully reviewed. Multi-layered PCBs can help to offset electrical density.

18.3 Other Components
Components such as mechanical switches, micro-processors, and integrated circuitry can be incorporated into membrane keyboard designs.

Assembly of these and other components can utilize either the front or rear mounting techniques described in the previous sections.

The use of flexible circuitry and multi-layered PCBs greatly enhances the design possibilities for component assembly.

Developing a module system requires considerable interaction between the customer and keyboard manufacturer. Consequently, the keyboard manufacturer should be involved at the earliest possible time in the design procedure.

18.4 Conductive Adhesives
Conductive adhesives enables L.E.D.s to be terminated to a flexible circuit. This technique is advantageous when mounting space requirements prevent a thicker lower PCB circuit from being used.

Conductive adhesives consists of a silver-based adhesive binder.

Chapter 19
Keyboard Mounting

When designing a keyboard, an understanding of various final mounting techniques can help you address the following fundamental concerns:

- Sealing the keyboard
- Static discharge protection
- Cleaning the keyboard
- Maintaining the keyboard

As a general rule, the benefits of a well-designed interface between the keyboard and its housing far outweigh cost considerations.

19.1 Adhesives

Many keyboard assemblies provide an acrylic adhesive as the rear mounting surface. This adhesive allows the customer to position the keyboard on the equipment during the final assembly.

Adhering the keyboard involves removal of a backer layer, which exposes the adhesive substance. In addition, positioning or locator holes can be supplied to ensure that the keyboard is properly positioned.

Once adhered to the equipment, the keyboard cannot generally be repositioned. There is, however, a 72-hour cure period required for the adhesive to initially bond. For this reason, "burn in" and environmental testing should not occur before the end of this time.

Section 5.1 contains a detailed listing of adhesives and their properties.

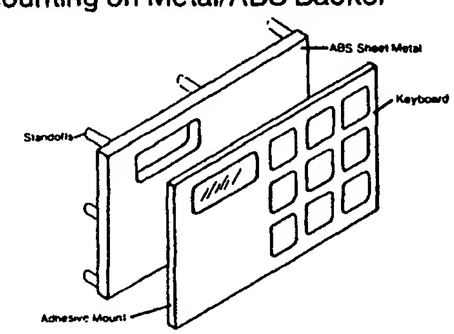
Note that adhesive mounting requires that the housing includes a rigid mounting surface which must be thoroughly cleaned before assembly.

19.2 Backer Types

A substrate can be adhered to the rear side of a keyboard to provide a rigid single unit assembly

Acrylic adhesive usually provides the bonding substance to adhere the rigid backer substrate to the keyboard. The rigid backer material typically consists of aluminum, ABS or Lexan (polycarbonate) plastics. Common thicknesses are .032", .062", .092" and 0.125"

Mounting on Metal/ABS Backer



The backer-mounted keyboard is affixed to the equipment by either heat stakes, standoffs, or studs. These can be incorporated onto the backer, or provisions can be made for them to be part of the equipment itself.

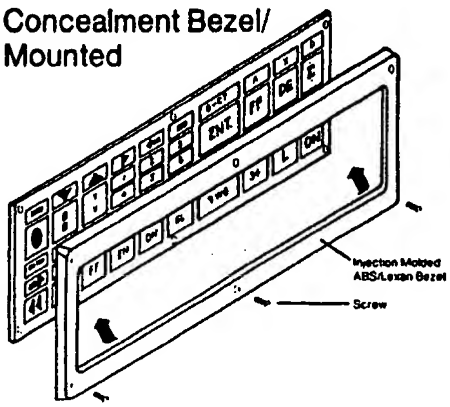
When suppression of internal component-generated RFI or EMI is important, an aluminum backer should be used. The aluminum surface supplies the necessary shielding or blockage of RFI or EMI. For optimum performance, the aluminum shield should be grounded directly to the equipment.

Backer mounted keyboards can be more easily repositioned than adhesive backed products. In many applications, the backer mounted keyboard is directly assembled to an internal PCB. This approach enables the final positioning and assembly of the keyboard to occur from the backside of the coverplate.

Positioning the keyboard in an undersized opening in the front panel protects the edges of the keyboard from the user and greatly increases E.S.D. protection.

19.3 Front Mounting Bezel
In keyboard designs utilizing adhesive mounting only, a front mounted perimeter bezel increases the protection and appearance of the keyboard.

Edge Concealment Bezel/
Front Mounted



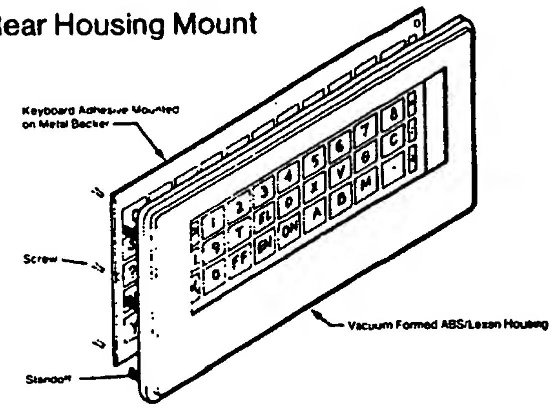
An adhesive on the rear of the keyboard is used to mount the keyboard on the equipment. Once mounted, a separate perimeter bezel with corresponding countersunk holes is then placed over the keyboard. The bezel is held in place by threaded screws which extend through the bezel and keyboard perimeter and lock into the equipment housing. Rubber gaskets can also be used in conjunction with the bezel for increased seal integrity.

The danger of electro-static discharge decreases when a bezel is added because it effectively conceals the edge of the keyboard, reducing the possibility of E.S.D. flashover and environmental contamination.

The perimeter bezel used in this design is typically injection molded, although small volumes are possible with vacuum form or routing techniques.

19.4 Rear Mounting
Keyboard designs that utilize the rigid backer mounting technique can increase their protection and appearance by incorporating rear mounting.

Rear Housing Mount



In this approach, the keyboard is mounted to the rear side of the front panel with studs and/or a standoff. A rubber gasket can be added for increased sealability from environmental contamination. The danger of electro-static discharge also decreases because the edge of the keyboard is effectively concealed, reducing the possibility of E.S.D. flashover.

The front panel cutout is smaller than the actual keyboard assembly. The user operates the keyboard through this opening in the panel.

Chapter 20
Forming/Cutting Tools

20.1 Forming Tactile Membrane
When choosing a tactile membrane design, a match mold tool set is required to form the domes. The tooling necessary is a machined bottom plate and matching molded top plate.

Tactile membrane keyboards are typically manufactured in what is termed a one up mode. This does not mean that each dome is formed individually but that each keyboard with all its associated domes is formed at one time.

Tolerance of the formed dome location is ± .005".

20.2 Embossing
Any type of graphic embossing requires a match mold tool set. The type of tooling required to emboss is similar to that needed for dome forming. All keyboards using a tactile membrane or tactile metal dome/PCB switch without an actuator layer require embossing to raise the graphic overlay keypads.

Embossing tools can sometimes be achieved in what is known as multi up format. The decision on using single or multi up embossing tooling is dictated by the size of the part and the quantity of the order.

20.3 Steel Rule Die
The most commonly used cutting tool for flexible layers is known as a steel rule die. These dies are manufactured using a gas laser beam which cuts a thin slot in a piece of 3/4" hard maple die board. Formed stainless steel blades are then inserted into this slot. Each sublayer of the keyboard configuration has its own specific steel rule die which match a precisely drawn blueprint for that particular layer.

A simple flat membrane switch may have as few as four steel rule dies while a more complex keyboard could have 8–10 dies. The life of a steel rule die is between five and seven thousand cutting impressions. Since size of the part and quantity ordered dictate singular or multi up tooling, a steel rule die could produce as few as 5,000 parts in a one up mode to as many as 70,000 parts in a ten up mode.

When higher quantities exist, multi sets of steel rule dies should be purchased to produce higher volumes.

Overall steel rule die tolerances are ±.010".

20.4 Hard Tooling
Hard tooling consists of a male and female machined steel tool set. When either volume or tolerance levels exceed those normally achieved with steel rule dies, hard tooling is suggested. Hard tooling, although more costly, can produce quantities in excess of 1 million units and a consistent tolerance level of ±.003". Quite often hard tooling will be used on specific sublayers of a keyboard, typicallly the circuit layers which include the flextail.

Chapter 21
Environmental Tests

21.1 Thermal Shock
Tested under Mil. Std. 202, Method 107D, Condition A.

This test determines the resistance of a part to exposure at extremes of high and low temperature, such as might occur when equipment or parts are transferred to or from heated shelters in Arctic areas. It also tests the effect of the shock of alternate exposures to these extremes.

The part is tested in a two hour dwell time between a low temperature of −55°C and a high temperature of 85°C. The tested part should not show change in operating characteristics or physical damage caused by the thermal shock, such as changes in electrical characteristics or mechanical displacement of dimensions causing delamination of insulating materials or finishes.

21.2 Humidity
Tested under Mil. Std. 202, Method 103B, Condition A.

This test evaluates the influence of absorption and diffusion of moisture vapor on component materials.

This accelerated environmental test involves the continuous exposure of the assembly to a 95% relative humidity at 40°C for a period of ten days.

The insulating materials in the assembly should not absorb moisture, which can cause swelling or harm any important mechanical characteristic or degrade any electrical property.

21.3 Moisture Resistance
Mil. Std. 202, Method 106E.

Similar to the humidity test, the moisture resistance test evaluates the resistance of component assembly parts to high humidity and heat conditions that typify tropical environments.

The test differs from Method 103 by providing alternate periods of condensation and drying which determines whether the circuitry develops any corrosion. The test should not detect any deterioration of electrical characteristics nor any discernable differentiation in resistance.

21.4 Salt Spray
Tested under Mil. Std 202, Method 101D, Condition A.

The salt spray test subjects the circuit component parts to a fine mist from a 5% salt solution creating a marine environment of ocean water atmosphere. The test determines resistance to salt spray corrosion and evaluates the uniformity, thickness, and degree of porosity of protective coatings on circuitry as well as the relative life and behavior of different conductive materials in an exposed seacoast or marine location.

The test should reveal no change in electrical characteristics (minor change in resistance if circuit exposed to the open atmosphere).

21.5 Solvent Resistance
Mil. Std. 202, Method 215A

This test verifies that component parts (including circuitry and graphics) do not become illegible or discolored when subjected to solvents normally used to clean fingerprints and other contaminants.

After immersing the component part in a liquid detergent solution and brushing it, there should be no deterioration of the material or finish, nor should the solvents cause any mechanical or electrical damage to the assembly.

21.6 Shock
Mil. Std. 202, Method 213B, Condition A.

This test exposes the circuit component subassembly to a shock that can be expected as a result of rough handling, transportation, or military operations.

The assemblies are exposed to a peak value of 50 g's over a normal duration of 11 milliseconds.

21.7 Vibration
Tested under Mil. Std. 202, Method 201.

This test determines the effects on component parts of vibration within the predominant frequency ranges and magnitudes that may be encountered during field service.

The result of the vibration should not cause a loosening of the subassembly parts or any motion between the parts that could cause a physical distortion resulting in any fatigue or failure of the switches.

21.8 Fungus
Tested under Mil. Std. 810C, Method 508.

This test creates a metabolic process causing a micro-organism fungus to grow. A humid, warm atmosphere with inorganic salts present is favorable to such growth.

The resulting micro-organisms can produce a living bridge across circuitry which can result in electrical failure and potential corrosion.

No electrical failures should result after a 28 day incubation period.

21.9 Dust or Fine Sand
Tested under Mil. Std. 810, Method 510.

The dust test ascertains the ability of an assembled keyboard to resist the effects of a dry dust or a fine sand atmosphere. The penetration of dust can form an electrical conductive bridge resulting in shorts and can also act as a nucleus for the collection of water vapor and hence serve as a source of possible corrosion and equipment malfunction.

The test should result in no discernable penetration of the dust into cracks or crevices of the keyboard and should not effect electrical performance.

21.10 Migration
Tested under Mil. Std. 202, Method 106.

The test for silver migration is the same as that for moisture resistance. The purpose is to determine whether condensation on the silver surface will cause any migration of silver particles.

The test should result in no shorting out or arcing.

21.11 Sulphur
This test creates a sulfur dioxide environment in order to determine whether there is any change in or loss of resistance.

After 10 days in 80% relative humidity at 60°C there should be no loss of resistance.

21.12 Fold
This test exposes a flexible circuit to the MIT fold endurance test.

After 200 cylces at 270' there should be an inconsequential increase in resistance.

21.13 Adhesion
Adhesion of conductive ink on film is performed by a tape pull test by using 3M #810 tape. This test should also be performed after thermal shock and humidity cyles.

21.14 Abrasion
The hardness of the silver and resistance to abrasion or scratching should be tested using a Hoffman scratch-hardness tester S6-1610M or by Method ASTM D3363-74 with a pencil border. The tests should reveal no marring after moderate pressure.

Glossary

Actuator—A formed or molded protrusion to make contact with the center of a switch location improving tactile feedback.

Analog—An encoding output that electronically identifies switch location by resistive values.

Bezel—A molded, routed, or die cut plastic frame mounted on the face or perimeter of a keyboard.

Common Buss—An encoding output that consists of one circuit lead for all switch locations or group of switches.

Contact Bounce—The time required for an electrical contact to be stable after closure.

Contact Rating—The maximum volts, amps, and watts electrically passed through a switch.

Curing—A process of drying conductive ink for maximum reliability.

Custom Keyboard—A custom design requiring special tooling.

Die Cut—To make an opening by means of a sharp edged steel knife set in a holding tool.

Emboss—A raised configuration accomplished with additional tooling.

EMI—Electro magnetic interference—electro magnetic force generally produced by electrical motors in operation.

Encoding—The assignment of electrical impulses to specific key locations.

ESD—electro-static discharge—static electricity accumulation on one surface area and discharged to another surface when they come near each other.

Flexible Keyboard—A keyboard designed with a non-rigid lower circuit.

Flexible Tail—The termination exit which is an integral part of a flexible circuit in all flexible membrane keyboards.

Folded Circuit—A low cost circuit construction technique where one flexible circuit is folded to form an upper and lower circuit.

Heat Stake—A bonding technique consisting of heating formed plastic pins to hold a keyboard assembly.

Interdigitated Finger Pad—A contact pad configuration that consists of two or three inputs that appear on the same contact surface.

Living Hinge Key—A key connected to a plastic hinge.

Matrix—An encoding method to arrange switch groups in particular rows and columns.

Migration—The leaching out of particles in a conductor when exposed to a high humidity and moisture environment.

Resistance—The contact ohms resistance of a closed switch, or circuit contact.

RFI—Radio frequency interference—high frequency radio waves.

Rigid Membrane—A membrane keyboard with a rigid lower PCB circuit.

Selective Texture—A surface coating to texture selective areas on a graphic overlay.

Shielding—A method to protect the keyboard from interference or static discharge

Shorting Pad—Conductive contacts printed on the upper layer of a switch.

Spacer—An insulating non-conductive substrate with opening at switch locations to separate the upper and lower circuit layers.

Tactile Feel—The snap action feel of domed keyboards with graphics or keytops, and the full stroke of full travel membrane keyboard.

Termination—The means to electrically connect the contact switches of a keyboard.

Travel—The downward movement of a key or the distance between the upper and lower contact.

Ultra-Sonic Weld—A bonding method of switch layers using high frequency sound waves.

Venting—An air channel cut in a spacer layer connecting groups of switch locations for air pressure equalization during switch closure.

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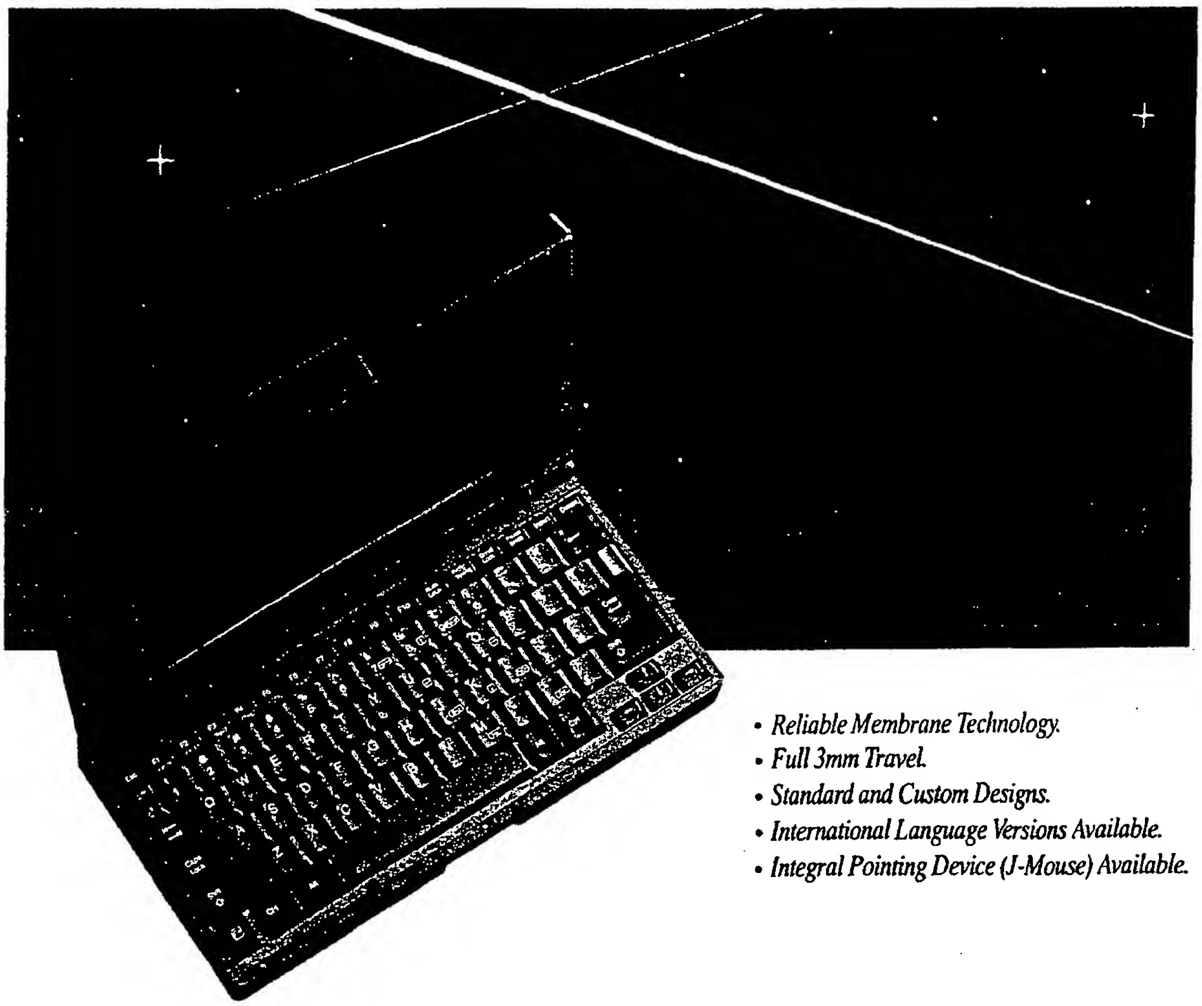
SEJIN NOTEBOOK KEYBOARDS



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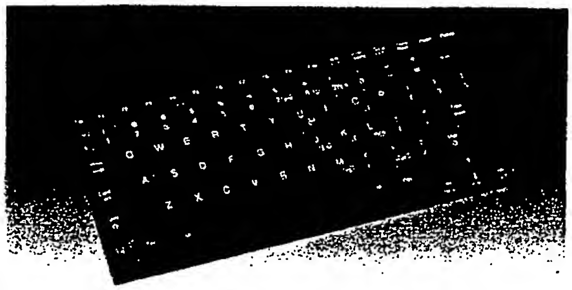
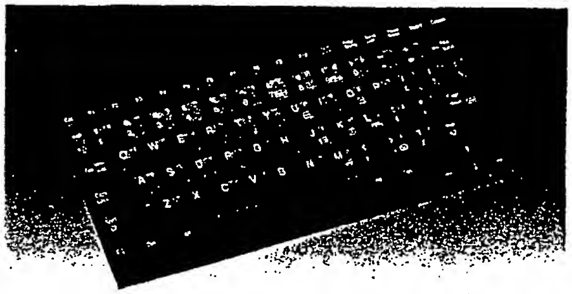


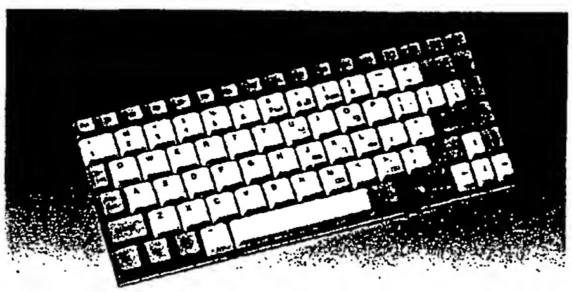
SNR-8011/ 8011J

KEY SWITCH TYPE	MEMBRANE WITH TACTILE
NUMBER OF KEYS	US : 80 KEYS, EUROPE : 81 KEYS
FULL STROKE	3.0±0.3mm
SIZE(W×L×H)	112.1mm×267.9mm×11mm
WEIGHT(ASS'Y)	170±15 gr
LIFE CYCLE	10,000,000 cycles
OPERATING FORCE	60±15gf
CONNECTOR PITCH	1.25mm
USER OPTION	J-MOUSE (SNR-8011J)



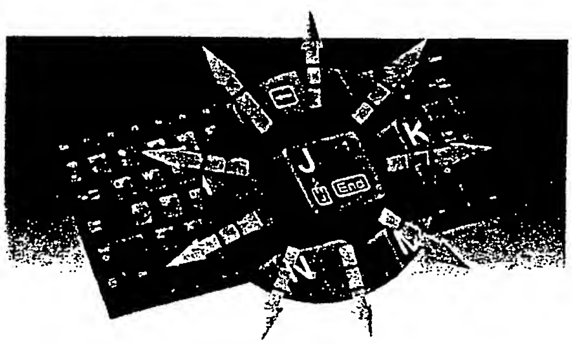
SNR-8012/ 8012J

KEY SWITCH TYPE	MEMBRANE WITH TACTILE
NUMBER OF KEYS	US : 80 KEYS, EUROPE : 81 KEYS
FULL STROKE	3.0±0.3mm
SIZE(W×L×H)	117.4mm×267.8mm×11mm
WEIGHT(ASS'Y)	170±15 gr
LIFE CYCLE	10,000,000 cycles
OPERATING FORCE	60±15gf
CONNECTOR PITCH	1.25mm
USER OPTION	J-MOUSE (SNR-8012J)



SNR-8020

KEY SWITCH TYPE	MEMBRANE WITH TACTILE
NUMBER OF KEYS	US, EUROPE : 85 KEYS
FULL STROKE	3.0±0.3mm
SIZE(W×L×H)	114.7mm×274mm×11mm
WEIGHT(ASS'Y)	190±20 gr
LIFE CYCLE	10,000,000 cycles
OPERATING FORCE	60±15gf
CONNECTOR PITCH	1.25mm



WITH J-MOUSE

- MOUSE DEVICE IS EMBEDDED IN THE J KEY
- KEYBOARD AUTOMATICALLY GOES INTO MOUSE MODE WHEN J KEY IS DEPRESSED AND HELD DOWN
- HANDS STAY ON THE HOME ROW
- MOUSE IS UNDER YOUR INDEX/POINTING FINGER
- NO EXTRA SPACE NEEDED FOR MOUSE

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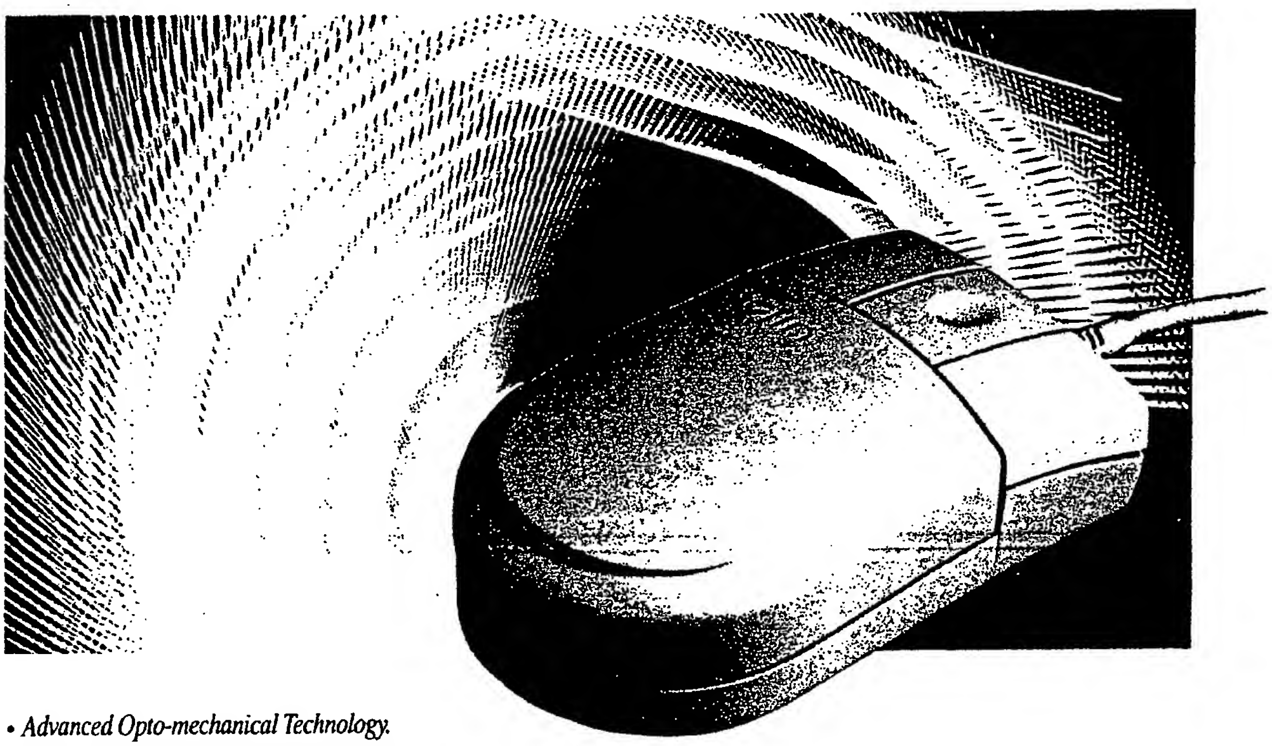

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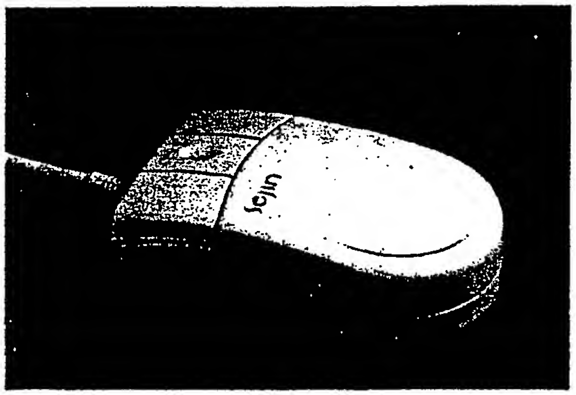
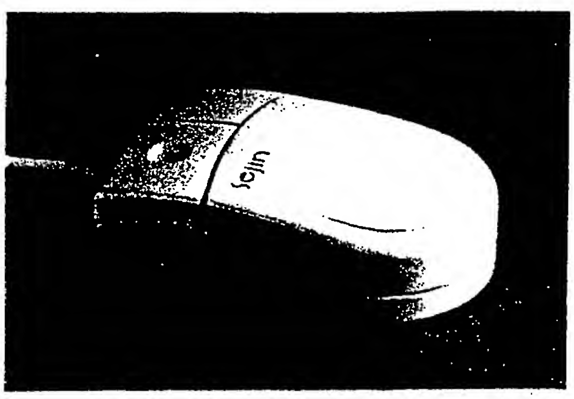


SMC-34-9 THREE-BUTTON, SERIAL

RESOLUTION	200~400 DPI
TRACKING SPEED	500mm/sec Max
BAUD RATE	1200 BPS
CONNECTION	RS-232C 9 Pin
SWITCH LIFE	300,000 cycles
MOUSE LIFE	50Km
MODE	HARDWARE: MOUSE SYSTEMS* or MICROSOFT*MODE DEFAULT(OPTION) SOFTWARE: MOUSE SYSTEMS*& MICROSOFT*MODE SELECTABLE

SMC-24-9 TWO-BUTTON, SERIAL

RESOLUTION	200~400 DPI
TRACKING SPEED	500mm/sec Max
BAUD RATE	1200 BPS
CONNECTION	RS-232C 9 Pin
SWITCH LIFE	300,000 cycles
MOUSE LIFE	50Km
MODE	HARDWARE : MICROSOFT* MODE SOFTWARE: MICROSOFT* MODE



SMC-24-6 TWO-BUTTON, PS/2 COMPATIBLE

RESOLUTION	100~400 DPI
TRACKING SPEED	500mm/sec Max
BAUD RATE	SYNC 9600 BPS
CONNECTION	MINI DIN 6 Pin
SWITCH LIFE	300,000 cycles
MOUSE LIFE	50Km
MODE	IBM PS/2* COMPATIBLE

*MICROSOFT is registered trademark of the Microsoft Corporation.
*MOUSE SYSTEMS is registered trademark of the Mouse Systems Corporation.
*IBM PS/2 is trademark of International Business Machine

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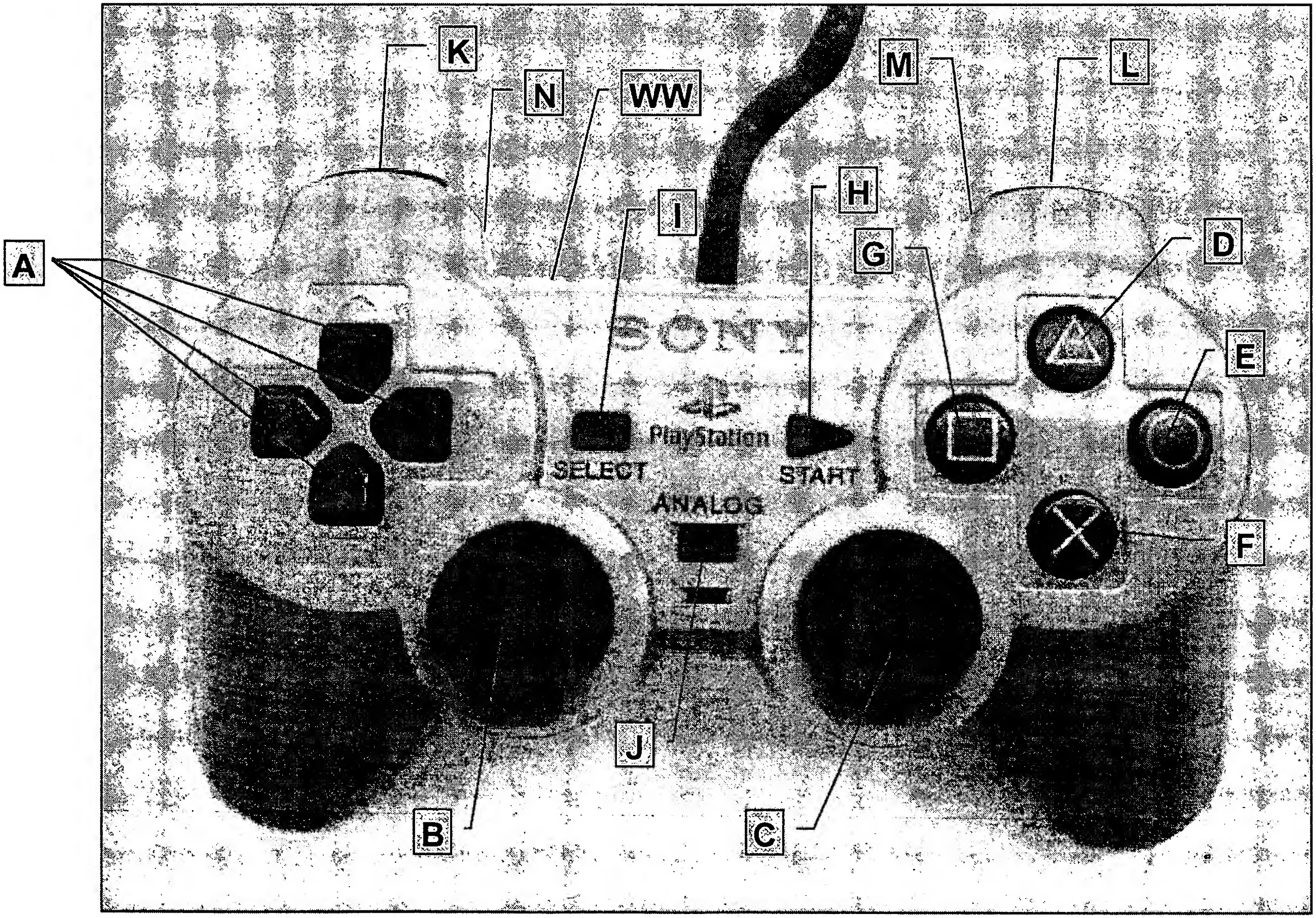
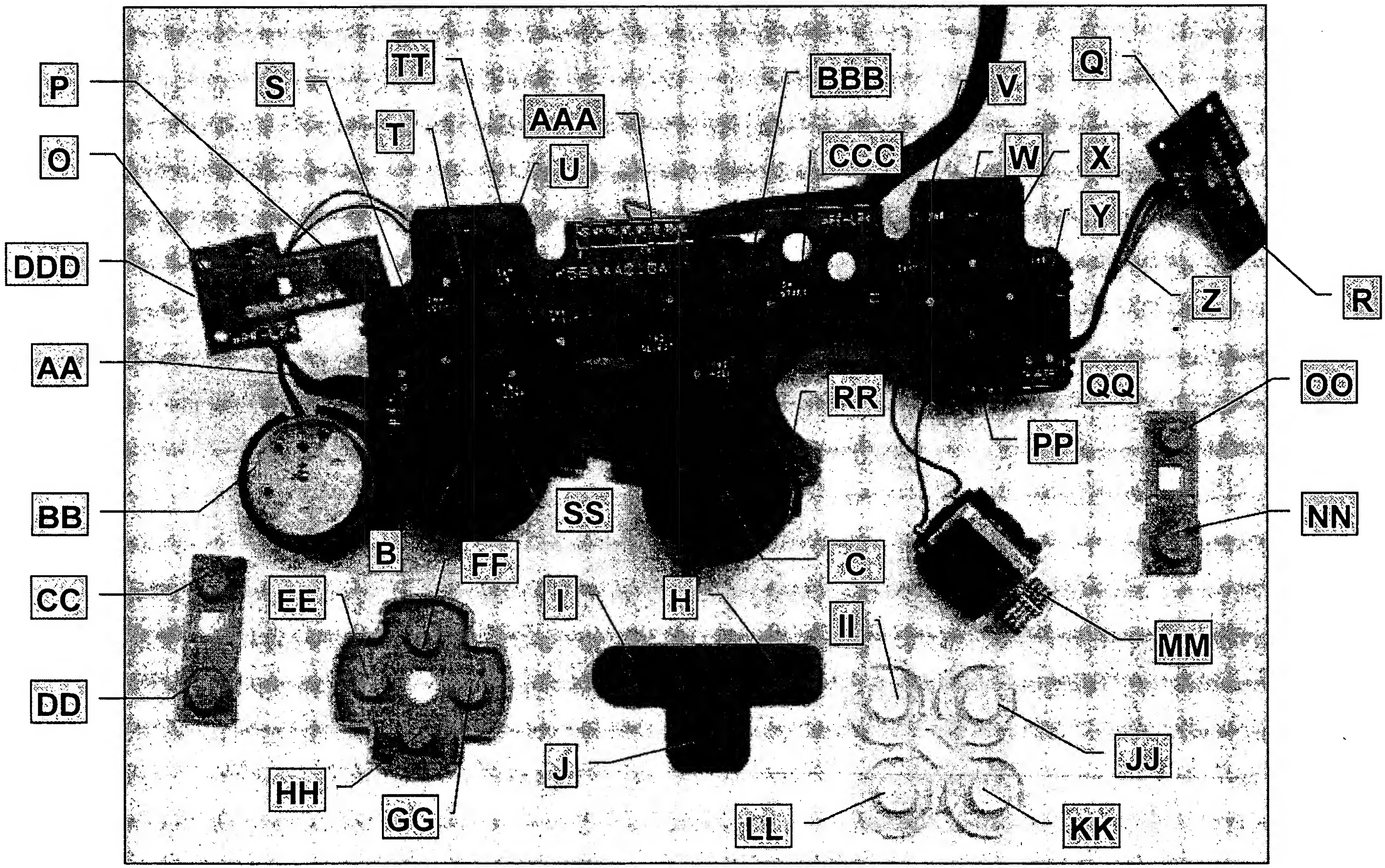
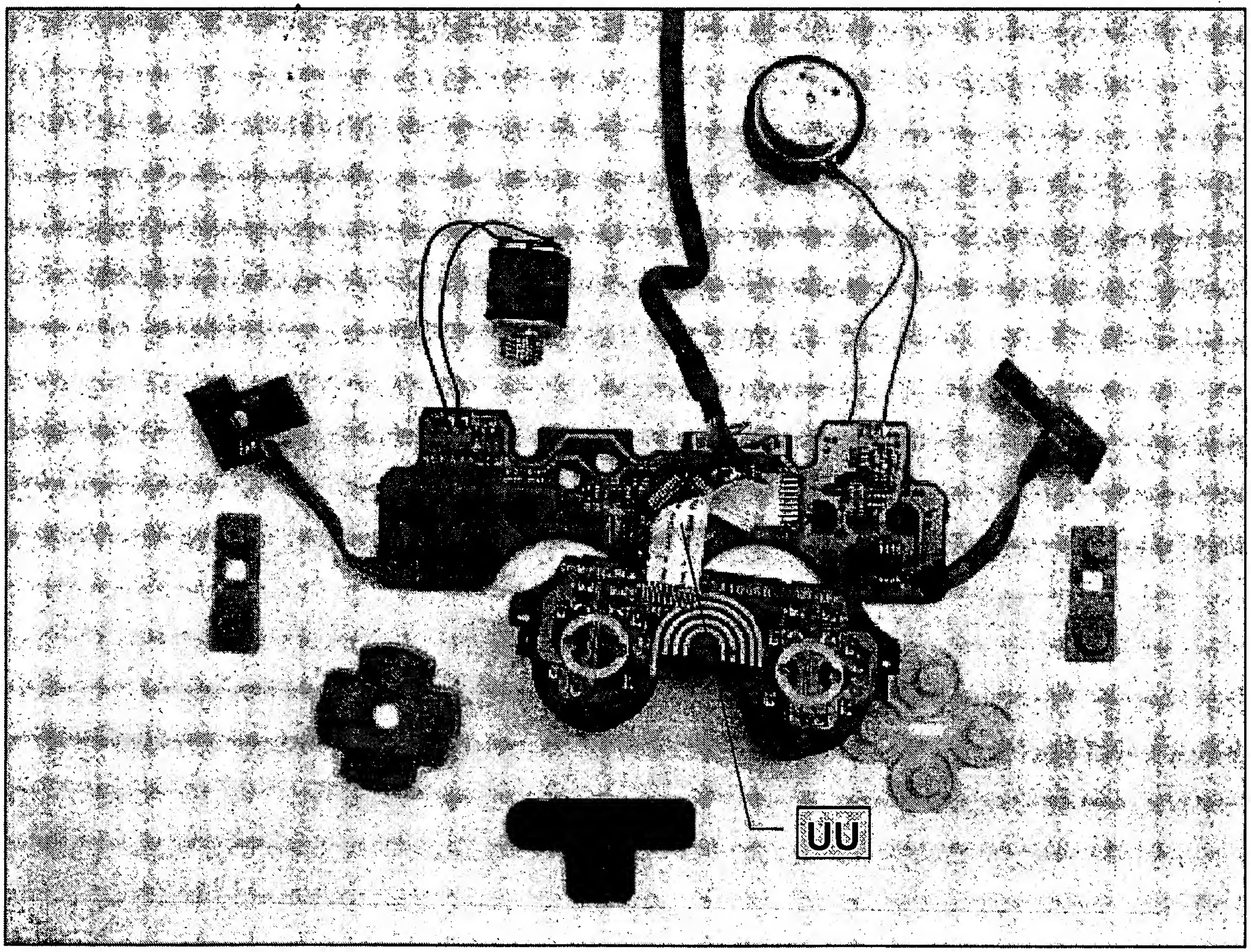
Sony Dual Shock Controller



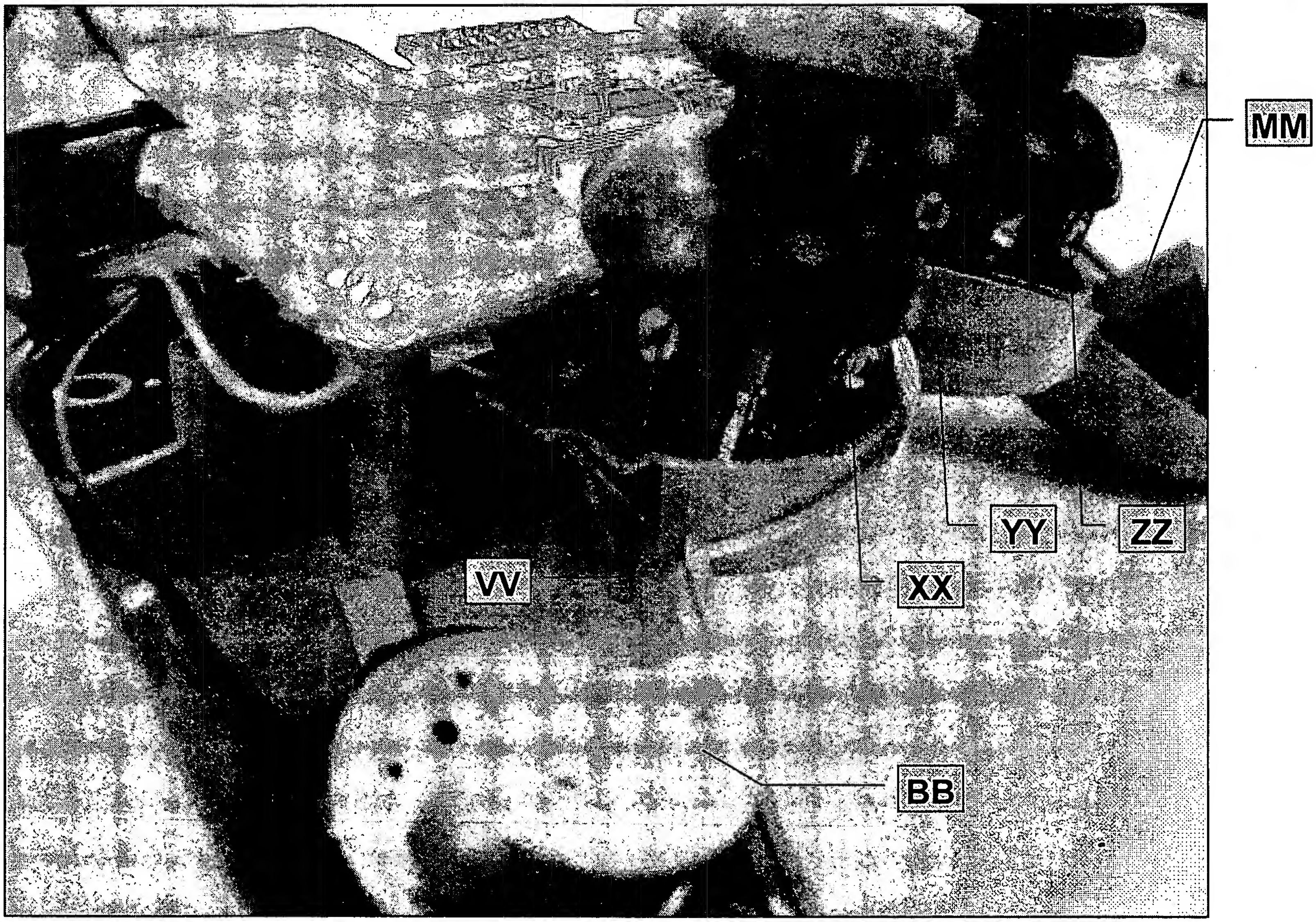
Sony Dual Shock Controller



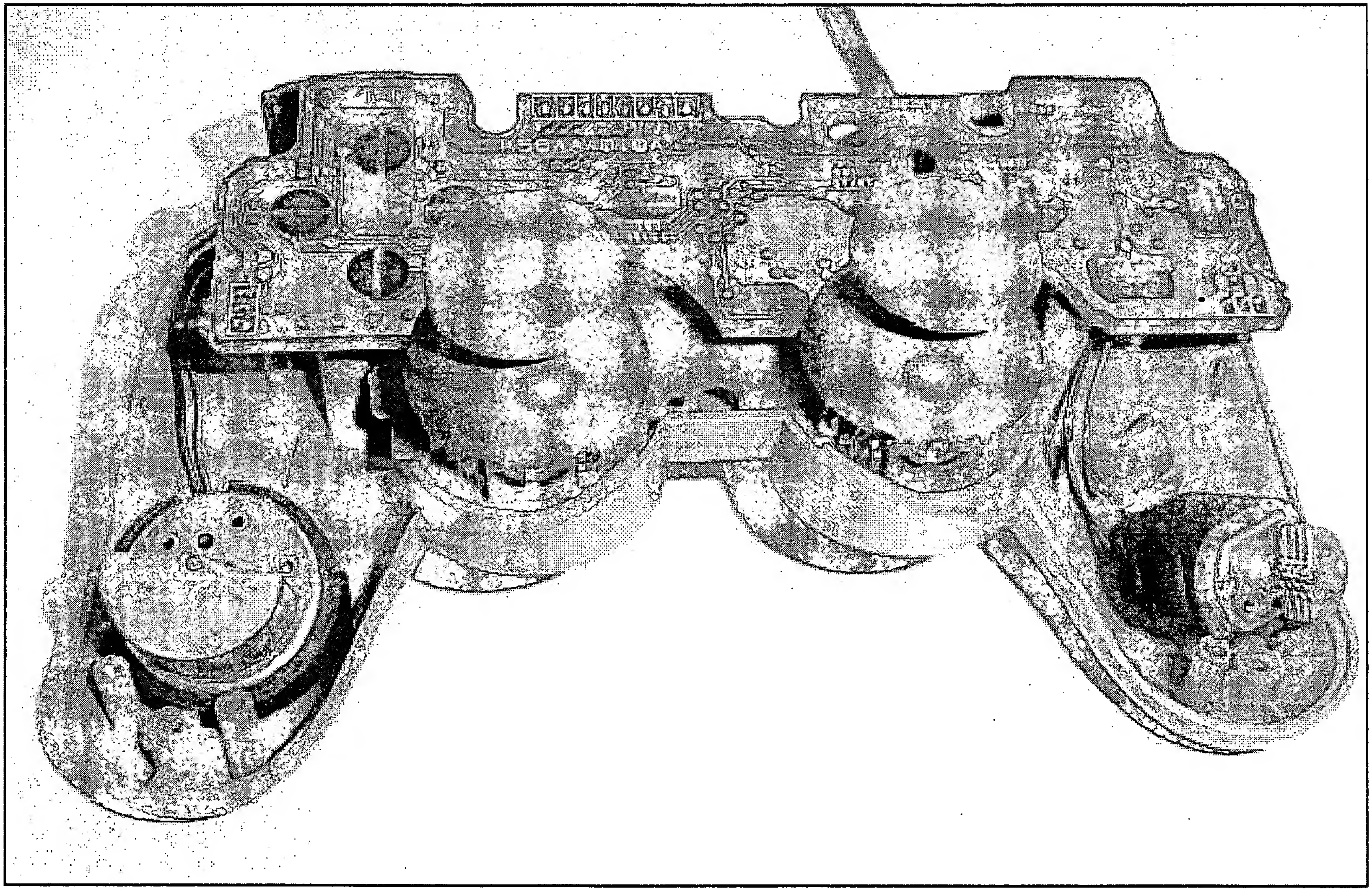
Sony Dual Shock Controller



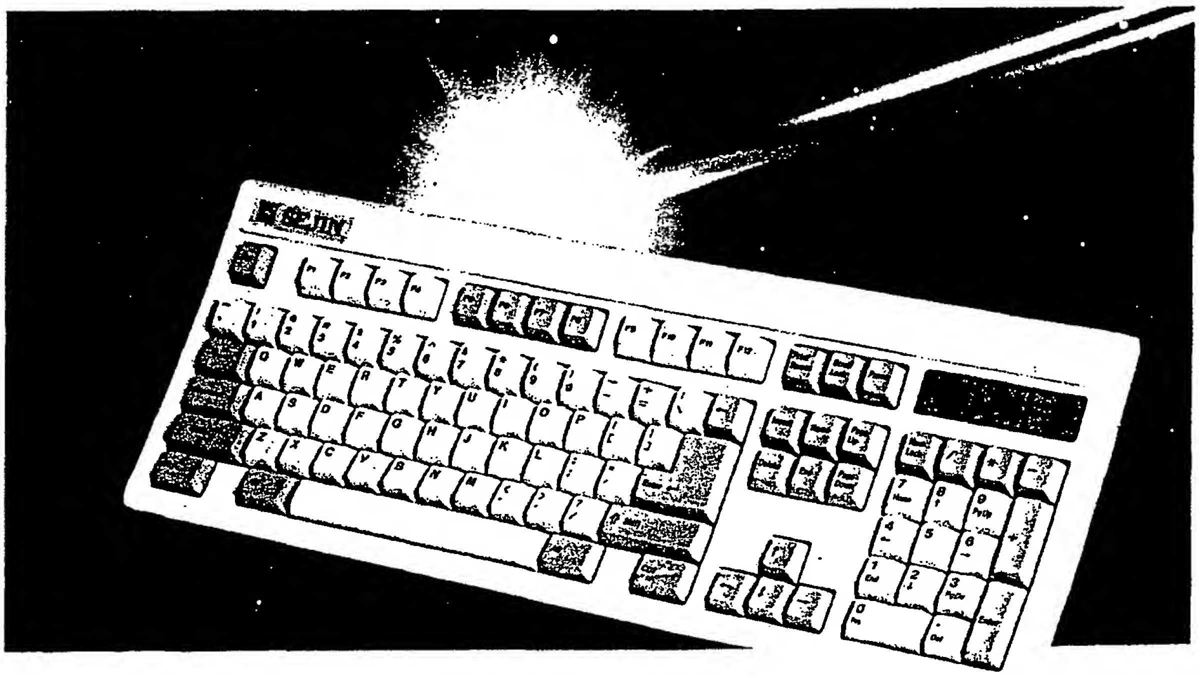
Sony Dual Shock Controller



Sony Dual Shock Controller



SEJIN DESKTOP KEYBOARDS



- Mechanical Click and Quiet Tactile Membrane Technology.
- Standard and Custom Designs.
- PC XT/AT,386,Novell Netware and PS/2 Compatible.
- International Language Versions Available.
- FCC,UL,CSA,FTZ,VDE Approved.

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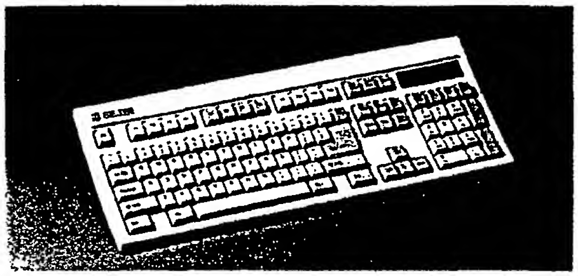
MAIN KEYBOARD PRODUCTS

INTERNATIONAL LANGUAGES AVAILABLE INCLUDE ARABIC, BELGIUM, FRENCH, CANADIAN BILINGUAL, CANADIAN FRENCH, DANISH, GERMAN, GREEK, ITALIAN, KOREAN, NETHERLANDS, NORWEGIAN, PORTUGUESE, RUSSIAN, SPANISH, SWEDISH, SWISS, AND TURKISH

EAT-1010M / EAT-1010R2

TYPE	MECHANICAL	MEMBRANE
NUMBER OF KEYS	101KEYS or 102KEYS	
COMPATIBILITY	IBM PC XT/AT* and PS/2*	
SWITCH STROKE	3.8±0.5mm	3.5±0.5mm
OPERATING FORCE	60±25gf	55±20gf
DIMENSIONS	SIZE: 475×195×40mm	WEIGHT: 1.5kg
AGENCY APPROVED	FCC, UL & CSA	FCC, UL, CSA, VDE, ZZF



SKM-1030 / SKR-1032

TYPE	MECHANICAL	MEMBRANE
NUMBER OF KEYS	101KEYS or 102KEYS	
COMPATIBILITY	IBM PC XT/AT* and PS/2*	
SWITCH STROKE	3.8±0.5mm	3.5±0.5mm
OPERATING FORCE	60±25gf	55±20gf
DIMENSIONS	SIZE: 460×170×40mm	WEIGHT: 1.2kg
AGENCY APPROVED	FCC, UL & CSA	FCC, UL, CSA, VDE, ZZF

EAT-1010B6

TYPE	MEMBRANE	
NUMBER OF KEYS	JIS 106KEYS	
COMPATIBILITY	IBM PC XT/AT* and PS/2*	
SWITCH STROKE	3.5±0.5mm	
OPERATING FORCE	55±20gf	
DIMENSIONS	SIZE: 475×195×40mm	WEIGHT: 1.5kg
AGENCY APPROVED	FCC, UL & CSA	

SKM-1070

TYPE	MECHANICAL	
NUMBER OF KEYS	107KEYS	
COMPATIBILITY	IBM PC XT/AT* and PS/2*	
SWITCH STROKE	3.8±0.5mm	
OPERATING FORCE	60±25gf	
DIMENSIONS	SIZE: 475×195×40mm	WEIGHT: 1.5kg
AGENCY APPROVED	FCC, UL & CSA	

SKR-1102

TYPE	MEMBRANE	
NUMBER OF KEYS	101KEYS or 102KEYS	
COMPATIBILITY	IBM PC XT / AT* and PS/2*	
SWITCH STROKE	3.5 ± 0.5mm	
OPERATING FORCE	55 ± 20gf	
DIMENSIONS	SIZE: 474 × 187 × 42 mm	WEIGHT: 1.5 Kg
AGENCY APPROVED	FCC, UL & CSA	

*IBM PC XT/AT and PS/2 are registered trademarks of the IBM corporation.

All specifications subject to change without notice

SEJIN

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INTERLINK ELECTRONICS

TECHNICAL OVERVIEW REV. 2/90

Force and Position Sensing Resistors

By
DR. STUART I. YANIGER
VICE PRESIDENT
AND CHIEF SCIENTIST

Contents

Abstract

Force Sensing Resistor™ devices (*FSR*™) superficially resemble a membrane switch, but unlike the conventional switch, change resistance inversely with applied force. For example, with a typical *FSR* sensor, a human finger applying from 10g to 1kg will cause the sensor to change resistance continuously from 400KΩ to 40kΩ. These sensors are ideal for touch control, and may be applied where a semi-quantitative sensor is called for that is relatively inexpensive, thin (>0.15mm), durable (10,000,000 actuations), and environmentally resistant. These sensors can be made into arrays or single elements up to 60cm x 80cm, and cover forces in the tens of grams to tens of kilograms range.

Force and Position Sensing Resistor™ devices (*FPSR*™) can sense the position and normal force of a single actuator, such as a finger or a stylus, along either a straight line (a Linear Potentiometer) or on a planar surface (an XYZ Pad). Depending on the mechanical arrangement, positional resolution of 0.05 mm is possible.

Introduction

Force and position sensing are integral to a wide range of dynamical measurements. These range from podiatric gait analysis to electronic music to computer input devices. New sensor options for the designer are the Force Sensing Resistor (*FSR*)and the Force and Position Sensing Resistor (*FPSR*).

We will first deal with the simpler *FSR*. The construction of a typical *FSR* is shown in figure 1, and is based on two polymer films or sheets. A conducting pattern is deposited on one polymer in the form of a set of interdigitating electrodes. The electrode pattern is typically on the order of 0.4 mm finger width and spacing.

Next, a proprietary semiconductive polymer is deposited on the other sheet. The sheets are faced together so that the conducting fingers are shunted by the conducting polymer. When no force is applied to the sandwich, the resistance between the interdigitating electrodes is quite high, usually 1MΩ or more. With increasing force, the resistance drops, following an approximate power law.

A typical plot of resistance versus force is shown in Figure 2.

Note that, unlike a conventional load cell or strain gauge, the *FSR* resistance changes by nearly 3 decades.

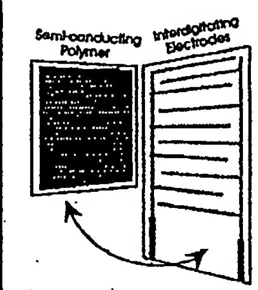


Figure 1.

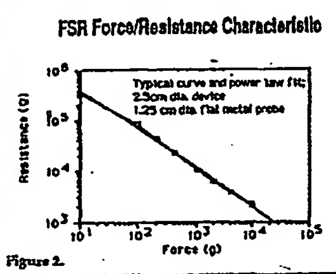


Figure 2.

With proper mechanical arrangement, repeatability of this curve cycle-to-cycle is better than ±2% over a specified force range. For the device from which the data in figure 2 was obtained (a 2.5 cm diameter circular *FSR*), the specified force range was 200 g-10 kg. Device-to-device variation is typically ±15% over that range.

Unlike piezoelectric transducers, the *FSR* is insensitive to vibration and acoustic noise pickup and is a slow device

The curve of Figure 2 does not show forces above a 10 kg load. At higher forces, the force/resistance characteristic starts to deviate from the power law response, eventually reaching a saturation force, beyond which the resistance does not vary strongly with force. The saturation force is a function of the ratio of the area of the applied force to the spacing between the *FSR* conductive interdigitating electrodes. As we will discuss, the finer the lines and spaces, for a given area of applied force, the higher the saturation force. With real world areas and sensors, this saturation force can be designed to be from 3-50 kg.

FSRs can be fabricated in various sizes, from 0.5 to 4800 cm^2, as single sensors or as arrays. The resistance range can also be tailored to specific applications. Varying the force range is also possible, but is best accomplished in the mechanical design. Zero travel is also a feature of the *FSR*. Where tactile feedback is desired, elastomeric overlays or molded domes can be laid over the parts to give travel or a tactile "snap."

The thickness of an *FSR* depends on several design variables. These include desired sensitivity, presence of overlays, and specified flexibility. Nearly all *FSR* designs to date have been in the thickness range of 0.1-1 mm.

Unlike piezoelectric transducers, the *FSR* is a slow device (typical mechanical rise time of 1-2 ms), and is relatively insensitive to vibration and acoustic noise pickup.

Effect of Mechanical Design on *FSR* Response

a. Area Effects

The force/resistance response of an FSR is an extremely sensitive function of the manner in which it is mechanically addressed. A true force sensor will give a constant reading at a constant force, independent of the area over which the force is applied, or its distribution. A true pressure sensor will give, with the same constant force, a reading which is inversely proportional to the area of the applied force.

The *FSR* lies somewhere between a force and a pressure transducer

In actuality, the FSR lies somewhere between a force and a pressure transducer. A typical *FSR* will show a resistance that varies roughly as the reciprocal of the square root of the area of the applied force. This holds true under the condition where the force footprint is smaller than the *FSR* active area, and large compared to the spacing between the conducting fingers.

The sensitivity of the *FSR* resistance to the area and distribution of the force means that either the FSR must be used as a qualitative sensor, or that by proper mechanical arrangement, the force footprint can be held constant in area, position, and distribution. Other tradeoffs must be considered in the actual sensor design; for example, tailoring the sensor for minimum creep under load conflicts with some application requirements that the *FSR* have a very large no-load resistance.

The *FSR* can be used as a pressure sensor when the applied force is large compared to the *FSR* active area. Semi-quantitative biomedical gauging has been accomplished by orthopedists attaching small *FSRs* to various body parts in configurations such that the force is constant across the sensor active area.

b. Actuator Characteristics

THE COMPLIANCE OF THE FORCE ACTUATOR IS A KEY ISSUE

The compliance of the force actuator (i.e., the actual component or finger that physically contacts and transfers force to the FSR) is also a key issue. Frequently, a rubber or other elastomeric overlay is placed over the part to help spread the force out, extending the dynamic range.

Figure 3 shows how a typical force/resistance characteristic is changed by the use of overlays of varying thickness and hardness (or durometer, Shore A). Note that the greatest effect is seen at low to intermediate forces.

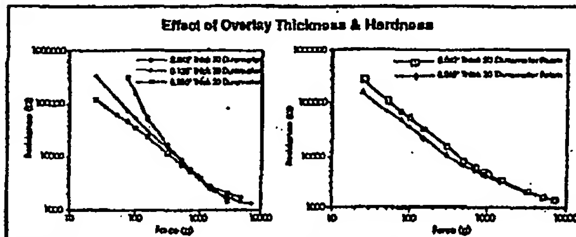


Figure 3.

c. Conductor Design

A KEY ELEMENT IN PROPER FSR SENSOR DESIGN IS THE FINENESS OF PITCH OF THE CONDUCTIVE FINGERS

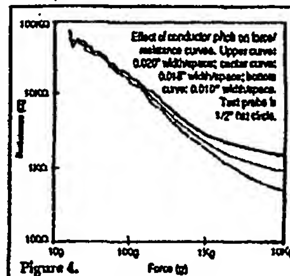


Figure 4.

A key element in proper *FSR* sensor design is the fineness of pitch of the conductive fingers. For a given area, the finer the pitch (or "space and trace"), the greater the number of fingers actuated. The effect of the greater number of shunted fingers can be seen to increase the dynamic range of the device. With a fine space and trace, the force-resistance characteristic maintains its power-law characteristic over a greater force range (i.e., linearity on a log-log plot). Additionally, there is often an increase in the slope of this characteristic (i.e., a larger exponent in the power law). For example, a standard *FSR* formulation was tested with 0.020", 0.015" and 0.010" (0.50, 0.38 and 0.25mm) conductor pitch. The results are plotted in Figure 4, and clearly show the performance advantages of the fine pitch.

The trade-off here is cost. With a finer space and trace, quality assurance inspection takes longer and the rejection rate is higher. This needs to be balanced against the real-world requirements of a given design.

DEVICE DURABILITY

THE FSR IS A RUGGED, DURABLE DEVICE

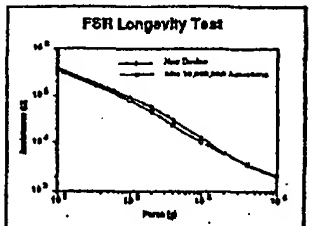


Figure 5. Test Conditions: 1/2" dia. circular probe; 10 million strikes at 82 psi, 0.5 sec/repetition

The *FSR* is a rugged, durable device. The temperature range of our standard devices extends to 170°C, continuous. Higher temperature range devices are also available, with use temperatures as high as 400°C (750°F). Typical temperature coefficients are in the range of 1000 ppm/kg/°C near room temperature. The *FSR* relatively insensitive to humidity.

Figure 5 shows the results of repeated use. For these data, a 2.5 cm diameter circular FSR was placed in a cycling force tester. A

12 lb. force was applied over ca. 1.5 cm², through a 3 mm thick 45 Shore A rubber foot. The force was applied and released at a 2.5 Hz rate, with a 50% duty cycle. A small change toward lower resistance is observed after 10,000,000 cycles; however, this represents less than a 5% deviation (logarithmic) from the new part characteristic.

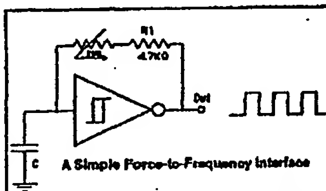
ELECTRICAL INTERFACING

As we have seen, the FSR changes resistance dramatically with applied pressure. Additionally, its impedance is nearly purely resistive. These properties make FSR electrical interfaces extremely simple. Unlike strain-gauge sensors with their low $\Delta R/R$, no bridge is needed in FSR circuits, and the signals are usually in the 0-5 volt range.

Two general rules must be kept in mind, however: first, the *FSR* force-resistance response characteristic is a power law, so it may make sense to measure the logarithm of resistance changes; second, the maximum permissible device current is about 1 milliamp per cm² of applied force. Typical *FSR* current excitation is in the tens of microamps. You can use the *FSR* to control larger loads by using suitable buffer circuits.

THE HIGH DYNAMIC RANGE OF THE FSR SIMPLIFIES ELECTRICAL INTERFACING

The most unpredictable part of the FSR force/resistance characteristic is the pressure range under about 100 grams/cm². If it is necessary to measure small forces in that range, you can pre-load the *FSR* with 100-200 grams/cm², and measure the change in resistance when the small load is applied. At a somewhat higher part cost, high sensitivity can be designed in (e.g., by using a thinner substrate), but it is generally more economical to achieve this in the *mechanical interface*.



A Simple Force-to-Frequency Interface

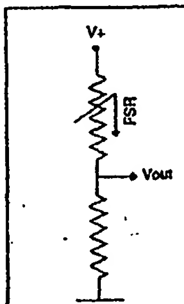
Figure 6.

The high dynamic range of the *FSR* simplifies electrical interfacing. For instance, a simple *force to frequency converter* is shown in Figure 6. In this circuit, the *FSR* is used as a feedback element around an inverter, with the time constant set by the *FSR* resistance and the capacitor. At zero force, the *FSR* resistance is very high, and the oscillator does not run. With increasing force, the output repetition rate is a linear function of the *FSR* resistance. R1 is included to *limit current* through the sensor. A great deal of control of the *force/frequency* curve is possible by including other elements in the feedback system. For example, bypassing R1 with a capacitor causes the curve to be steeper at higher forces; connecting a large value resistor in parallel with the capacitor C quenches any tendency to oscillate at low applied forces.

Analog interfaces are also quite simple. The *FSR* is placed in series with a current source (*current kept within the maximum FSR rating*). The voltage *measured across the FSR* is then related to the applied force. Alternately, the *FSR* can be used as one element in a voltage divider, with a fixed resistor as the other element. A voltage is applied to the divider, and the output voltage, taken from the resistor/*FSR* junction, is measured (Figure 7).

RUGGEDIZED KEYPADS EVEN WITHSTAND HAMMERS

This type of interface is quite adequate for qualitative force sensing (for example, a touch panel). Precision measurements, however, are difficult, due to the shape of the power law curve. For higher precision measurements, it is usually most economic to go to the digital domain as soon as possible so that the log/log characteristic of the device can be translated to something more linear. If a design calls for a measurement of an impact (for example, a data entry keypad adhered behind a rigid plate) the *FSR* can be placed in a voltage divider, as above, and the junction of the voltage divider capacitively coupled to the succeeding stages. This eliminates any offset problems due to a preload. In the application just cited, denting the keypad protective *plate with a hammer did not affect the operation of the pad*; the offset created by the constant resistance of the FSR under the dent was blocked by the coupling capacitor.



Analog Interface

Figure 7.

INTERLINK ELECTRONICS

TECHNICAL OVERVIEW REV. 2/90

Force and Position Sensing Resistors

By
Dr. Stuart I. Yaniger
Vice President
and Chief Scientist

Contents

Abstract

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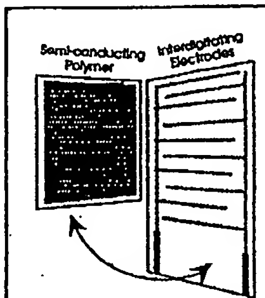
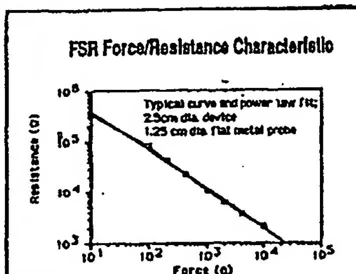


Figure 1.

UNLIKE PIEZOELECTRIC TRANSDUCERS, THE *FSR* IS INSENSITIVE TO VIBRATION AND ACOUSTIC NOISE PICKUP AND IS A SLOW DEVICE



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THE *FSR* LIES SOMEWHERE BETWEEN A FORCE AND A PRESSURE TRANSDUCER

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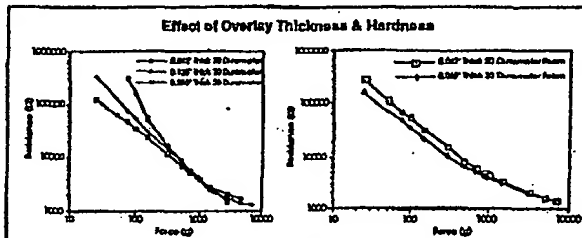

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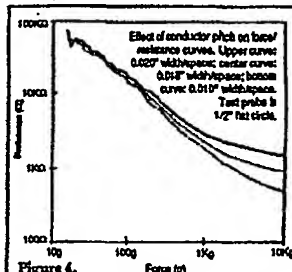

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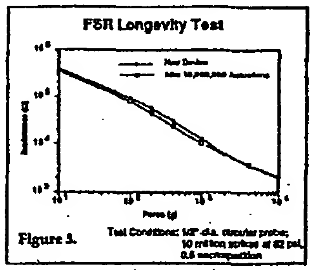

Figure 5.

12 lb. force was applied over ca. 1.5 cm^2, through a 3 mm thick 45 Shore A rubber foot. The force was applied and released at a 2.5 Hz rate, with a 50% duty cycle. A small change toward lower resistance is observed after 10,000,000 cycles; however, this represents less than a 5% deviation (logarithmic) from the new part characteristic.

Electrical interfacing

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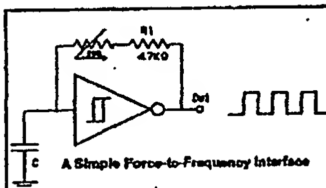
The most unpredictable part of the FSR force/resistance characteristic is the pressure range under about 100 grams/cm^2. If it is necessary to measure small forces in that range, you can pre-load the *FSR* with 100-200 grams/cm^2, and measure the change in resistance when the small load is applied. At a somewhat higher part cost, high sensitivity can be designed in (e.g., by using a thinner substrate), but it is generally more economical to achieve this in the mechanical interface.



A Simple Force-to-Frequency Interface

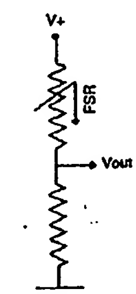
Figure 6.

The high dynamic range of the *FSR* simplifies electrical interfacing. For instance, a simple force to frequency converter is shown in Figure 6. In this circuit, the *FSR* is used as a feedback element around an inverter, with the time constant set by the *FSR* resistance and the capacitor. At zero force, the *FSR* resistance is very high, and the oscillator does not run. With increasing force, the output repetition rate is a linear function of the *FSR* resistance. R1 is included to limit current through the sensor. A great deal of control of the force/frequency curve is possible by including other elements in the feedback system. For example, bypassing R1 with a capacitor causes the curve to be steeper at higher forces; connecting a large value resistor in parallel with the capacitor C quenches any tendency to oscillate at low applied forces.

Analog interfaces are also quite simple. The *FSR* is placed in series with a current source (current kept within the maximum *FSR* rating). The voltage measured across the *FSR* is then related to the applied force. Alternately, the *FSR* can be used as one element in a voltage divider, with a fixed resistor as the other element. A voltage is applied to the divider, and the output voltage, taken from the resistor/*FSR* junction, is measured (Figure 7).

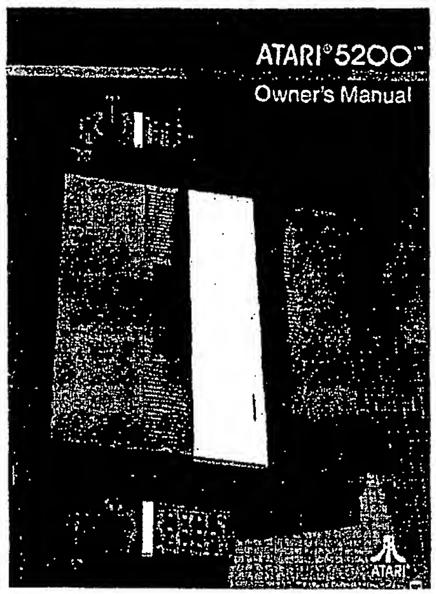
RUGGEDIZED KEYPADS EVEN WITHSTAND HAMMERS

This type of interface is quite adequate for qualitative force sensing (for example, a touch panel). Precision measurements, however, are difficult, due to the shape of the power law curve. For higher precision measurements, it is usually most economic to go to the digital domain as soon as possible so that the log/log characteristic of the device can be translated to something more linear. If a design calls for a measurement of an impact (for example, a data entry keypad adhered behind a rigid plate) the *FSR* can be placed in a voltage divider, as above, and the junction of the voltage divider capacitively coupled to the succeeding stages. This eliminates any offset problems due to a preload. In the application just cited, denting the keypad protective plate with a hammer did not affect the operation of the pad; the offset created by the constant resistance of the *FSR* under the dent was blocked by the coupling capacitor.



Analog Interface

Figure 7.


ATARI® 5200™
Owner's Manual
ATARI

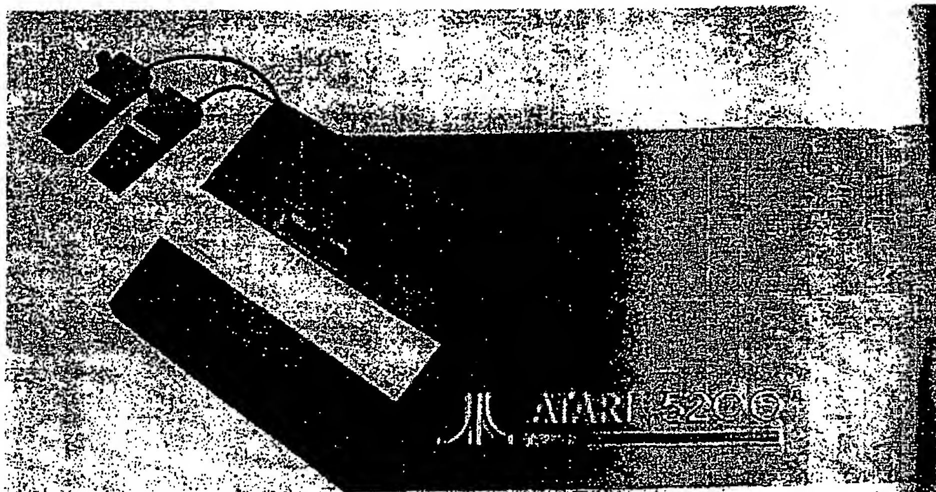


Table of Contents

1. Unpacking Your ATARI 5200

Congratulations on your purchase of one of the most exciting video game systems available. We suggest that you read this Owner's Manual thoroughly before setting up your ATARI 5200.

NOTE: Read this manual carefully and completely set up your ATARI 5200 before plugging in the power adapter.

When you remove your ATARI 5200 from the box, you will have:

- 5200 Console Unit
- SUPER BREAKOUT™ Game Cartridge
- Two 5200 Controllers
- TV Antenna Switch Box
- Power Adapter
- 300 OHM to 75 OHM TV Switch Box Adapter

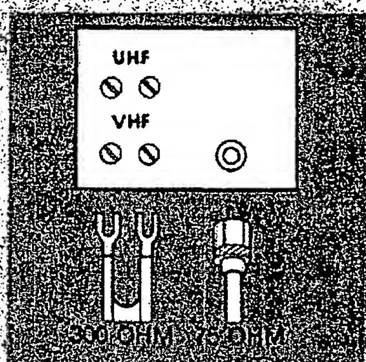
Note: Your ATARI 5200 is packaged with a protective plastic coating. To remove the plastic, refer to page 11 of this Owner's Manual.

NAA00005250

2. Installing the TV Antenna Switch Box

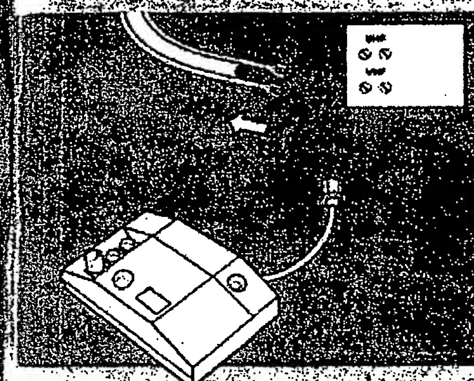
The TV Antenna Switch Box is easy to attach to the VHF antenna terminal on the back of your television set. Carefully inspect the antenna connection at the back of your television set to determine whether your present antenna is 300 ohms (flat twin-lead wire) or 75 ohms (round cable).

Follow the instructions (paragraphs A through E) which most closely apply to your television set antenna. If your television set is 300 ohms, you will need a flat blade screwdriver to install the switch box. THE TV SWITCH BOX ADAPTER IS NOT NECESSARY IF YOUR TELEVISION SET IS 75 OHMS.

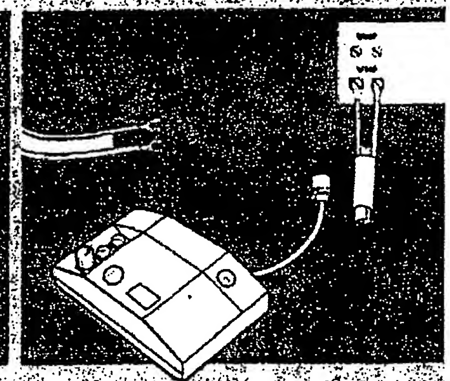


CAUTION: Do not use this TV Antenna Switch Box with any unit other than the 5200. Severe damage to the unit can result if this Switch Box is used with any other unit.

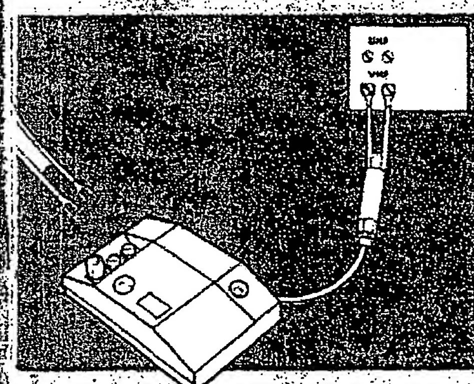
A. Television Set with VHF Screws and Twin-lead Wire Antenna:



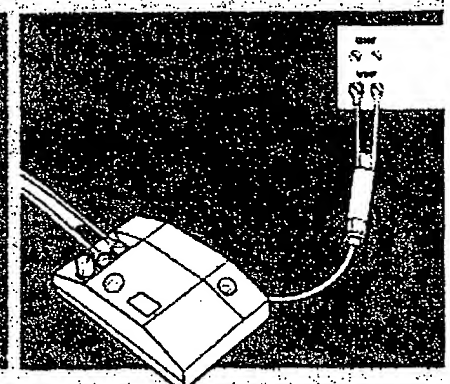
1. Disconnect the twin-lead antenna wire from the back of your television set.



2. Connect the twin-lead wire on the Switch Box Adapter to the VHF screw terminals on your television set.



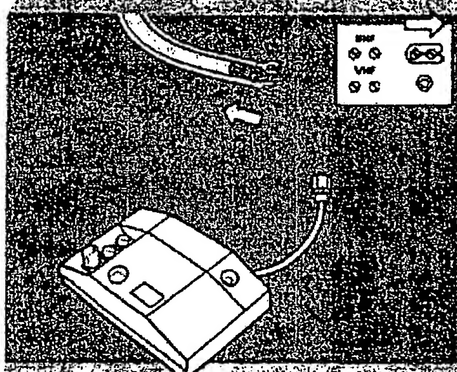
3. Connect the antenna cable on the TV Antenna Switch Box to the 75 ohm connector on the Switch Box Adapter. Securely tighten the connection.



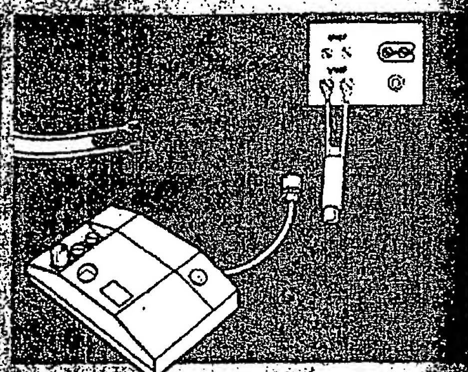
4. Connect the television twin-lead antenna wire to the 300 OHM connector on the TV Antenna Switch Box.

NAA00005251

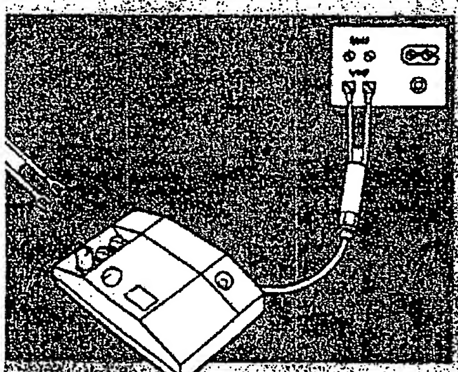
B. Television with U-Shaped Slider Switch and Twin-lead Wire:



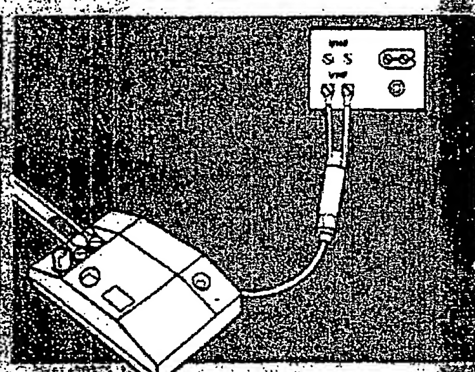
1. Disconnect the twin-lead antenna wire from the VHF screw terminals. Move the U-shaped slider to the right to make a connection between the two screws.



2. Connect the twin-lead wire on the Switch Box Adapter to the VHF antenna screws on the back of your television set.

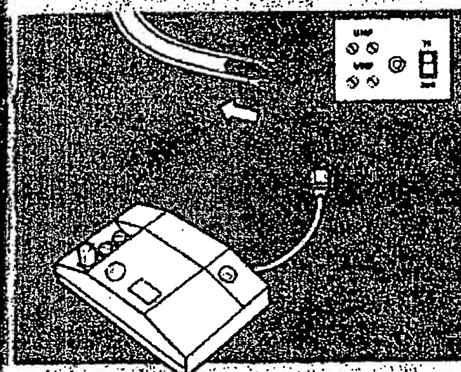


3. Connect the television twin-lead wire to the 300 OHM connector on the TV Antenna Switch Box.

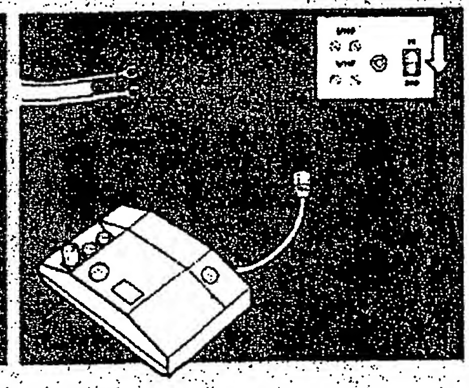


4. Connect the antenna cable on the TV Antenna Switch Box to the cylinder-shaped 75 ohm connector on the Switch Box Adapter.

C. Television with 75 OHM/300 OHM Slide Switch and Twin-Lead Wire:

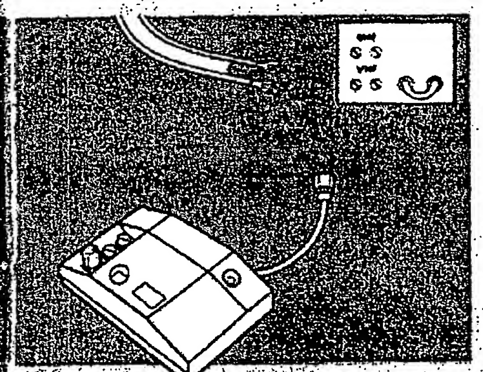


1. Disconnect the twin-lead antenna wire from the VHF screw terminals.



2. Slide the switch to the 300 OHM position and follow steps B-2 through B-4.

D. Television with a Short Round Cable and Twin-lead Wire:

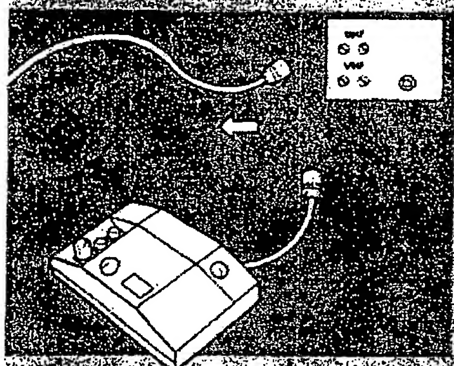


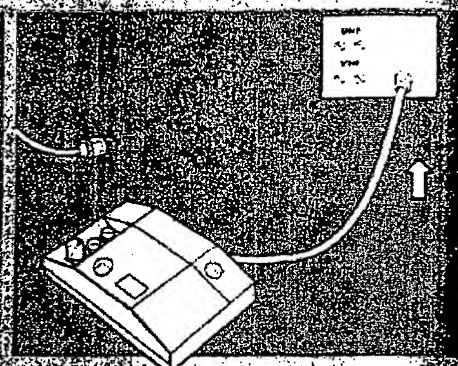
1. Connect the short round cable to the cable connector provided next to it on your television set. Then follow steps B-2 through B-4.

NOTE: For some televisions, the 75 OHM connector may not work correctly. If this is the case, no playfield will appear after you insert a cartridge and press the POWER switch on the console. To correct this problem, simply treat your television as though it is 300 ohms. Then follow steps A, B, C, or D.

NAA00005252

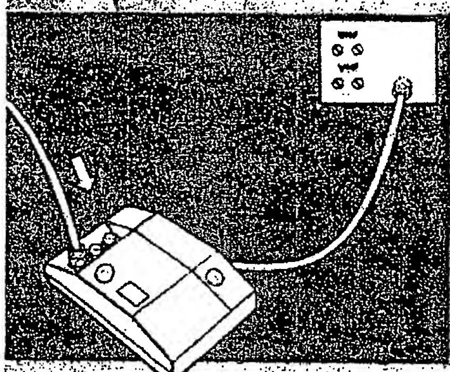
E. Television with 75 OHM Antenna Cable and VHF Screws:





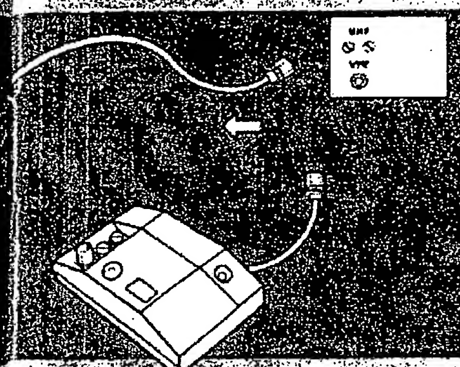
1. Disconnect the antenna cable from the cable connector or impedance-matching adapter (balun) on the back of your television set.

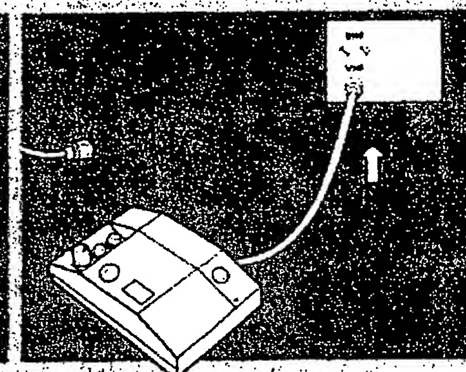
2. Connect the antenna cable on the TV Antenna Switch Box to the cable connector on your television set or the impedance-matching adapter. Securely tighten the connection.



3. Connect the antenna cable on your television set to the 75 OHM connector on the TV Antenna Switch Box.

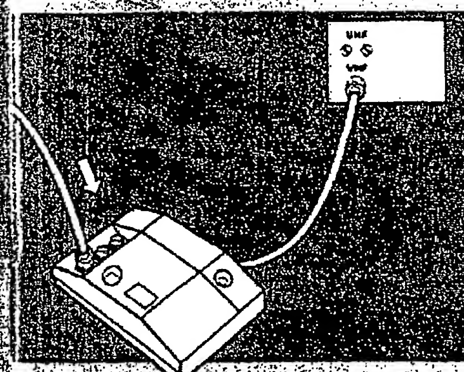
F. Television with Round Antenna Cable and No VHF Screws:





1. Disconnect the round antenna cable from your television set.

2. Connect the antenna cable on the TV Antenna Switch Box to the 75 ohm (cylinder-shaped) connector on the back of the television set.



3. Connect the television antenna cable to the 75 OHM connector on the TV Antenna Switch Box.

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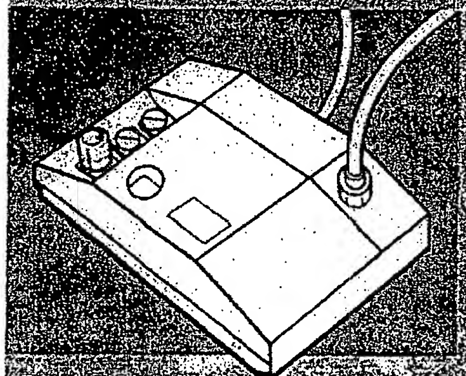
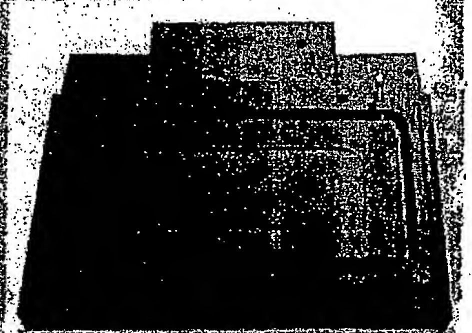
Plugging In the Game Cable





Plug the Game Cable on the console unit into the TV Antenna Switch Box GAME connector.

Excess cable can be wrapped around the cable wrap on the bottom of the console unit.

The TV Antenna Switch Box can be left attached to your television set without interfering with television program viewing or reception.

To attach the TV Antenna Switch Box permanently to the back of your television set:

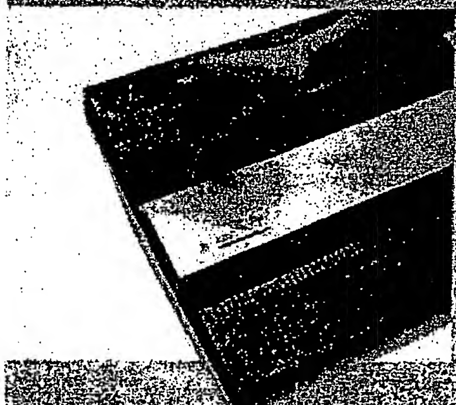
- Peel off the protective paper on the back of the TV Antenna Switch Box.
- Stick the TV Antenna Switch Box onto any clear area near the antenna terminals on the back of your television set.

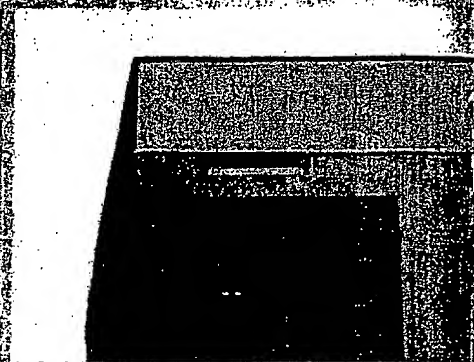
On the bottom, right side of the TV Antenna Switch Box, you will notice a switch labeled STANDBY/NORMAL. The NORMAL position is the correct position during regular use of your ATARI 5200. Changing this switch to the STANDBY position allows you to view regular television programs while the 5200 is still on. This feature allows you to save a high score on the screen. It also allows a game to continue running or the computer to take its turn while you watch television. To return to the game playfield, simply move the switch back to the NORMAL position.

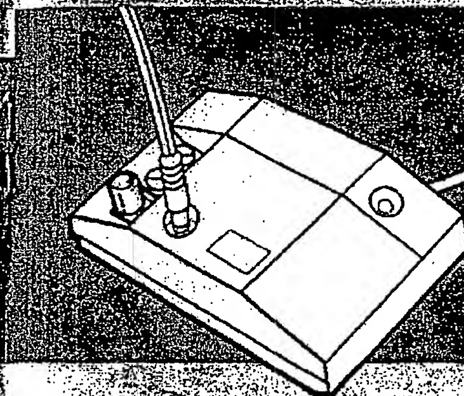
Extra TV Antenna Switch Boxes

If you attach a TV Antenna Switch Box to each television set in your home, you will be able to move your ATARI 5200 from room to room. Extra TV Switch Boxes are available through your local ATARI dealer.

3. Setting Up The Console







1. Peel off the protective coating on the top of the console unit.

2. Check the channel selector switch on the back, left side of the console to be sure it is set to ●.

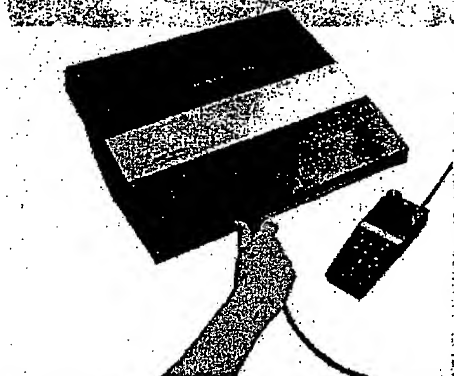
3. Set your television set channel selector to Channel 3. If Channel 3 is broadcasting in your area, set the television channel selector switch to Channel 2 and change the channel selector switch on the console unit to ■.

4. Insert the Power Adapter cable jack into the POWER plug on the TV Switch Box.

WARNING: Verify that the Game Cable is plugged into the TV Switch Box before plugging the Power Adapter into the TV Switch Box.

5. Plug the Power Adapter into any convenient 120 volt AC electrical wall outlet.

IMPORTANT: Use only the Power Adapter packed with your ATARI 5200. Use of any other power supply could damage the console unit.



6. Turn your television set on and set the volume control to a comfortable level.

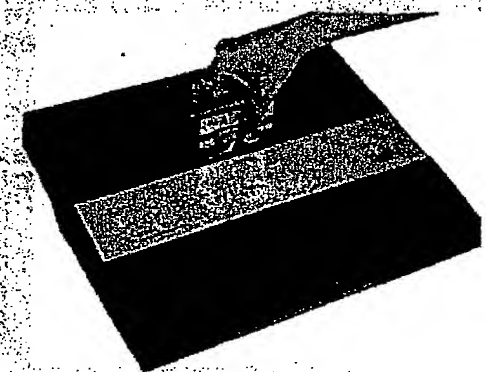
7. Press the POWER ON/OFF switch on the lower right side of the console to ON. A red light (LED) glows when the POWER is ON. When the POWER is OFF, the Switch Box automatically switches back to regular television viewing.

NOTE: Always turn the POWER OFF when the game is not in use.

8. If your television set has an automatic fine-tuning control, turn it off and manually fine-tune for the best picture. However, if your television set will not receive color unless the automatic fine-tuning is on, leave it on.

9. Plug the 5200 controllers into the controller jacks on the front of the console unit. Use jack 1 for one-player games; use jacks 1 and 2 for two-player games. For three and four-player games, you will need to purchase an additional set of 5200 controllers. Plug the second set of 5200 controllers into jacks 3 and 4. (See also USING THE 5200 CONTROLLERS.)

4. Inserting a Game Cartridge



1. Hold the game cartridge so the name on the label faces you and reads right-side-up.

2. Carefully insert the game cartridge into the cartridge slot in the 5200 console. Be sure the cartridge fits firmly into the slot but DO NOT FORCE IT IN.

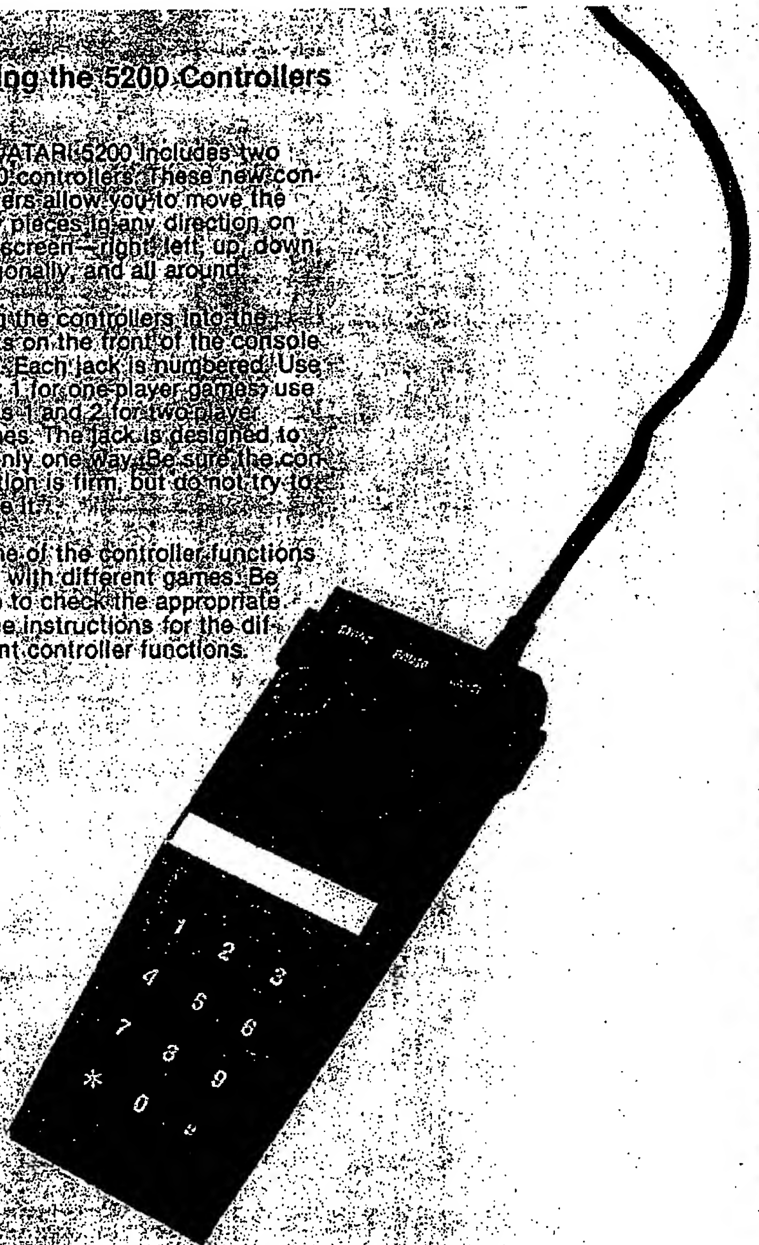
3. Press the console POWER ON/OFF switch. A bright, colorful ATARI logo will appear on your television screen, followed by the game play-field.

5. Using the 5200 Controllers

The ATARI 5200 includes two 5200 controllers. These new controllers allow you to move the play pieces in any direction on the screen—right, left, up, down, diagonally, and all around.

Plug the controllers into the jacks on the front of the console unit. Each jack is numbered. Use jack 1 for one-player games; use jacks 1 and 2 for two-player games. The jack is designed to fit only one way. Be sure the connection is firm, but do not try to force it.

Some of the controller functions vary with different games. Be sure to check the appropriate game instructions for the different controller functions.



Each controller has two fire buttons on either side. The bottom buttons are the fire buttons for all games. The top buttons are used for different functions depending on the particular game. Again, see the specific game instructions for the different controller functions. The right or the left fire button can be used, whichever is more comfortable for you.

The **START**, **PAUSE**, and **RESET** buttons on the controllers perform the following functions:

START Press **START** to begin game play.

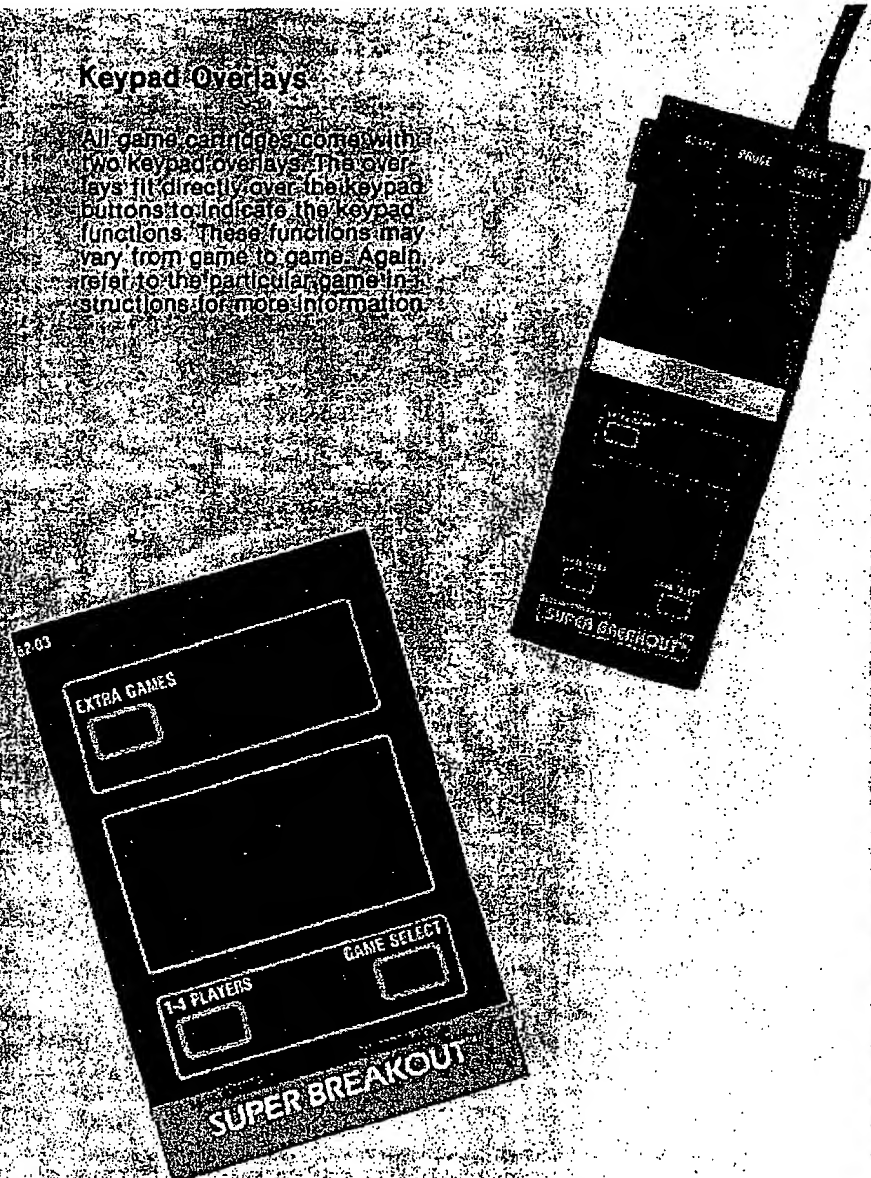
PAUSE Press **PAUSE** to stop all game action for an intermission. This feature allows you to leave the game without interrupting the game or score. Press PAUSE again when you are ready to resume the game.

Press **RESET** only when you want to start the game over from the beginning.

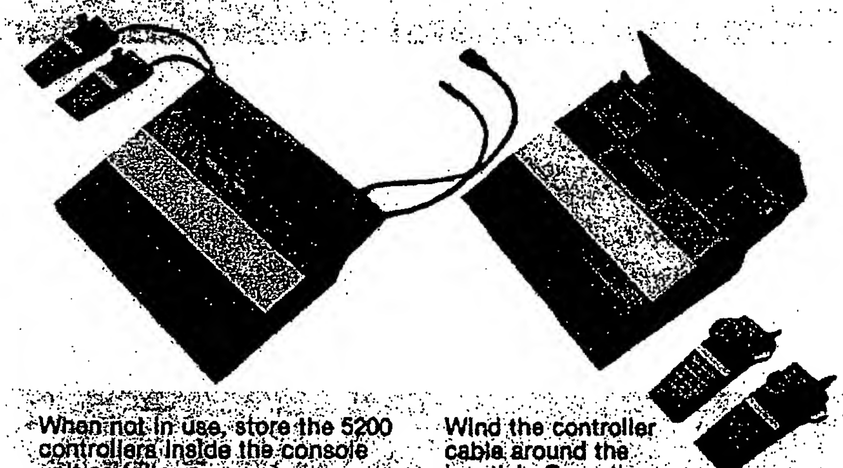
The # controller button and the * controller button are used to select different game options. Again, refer to the particular game instructions for further details.

Keypad Overlays

All game cartridges come with two keypad overlays. The overlays fit directly over the keypad buttons to indicate the keypad functions. These functions may vary from game to game. Again, refer to the particular game instructions for more information.

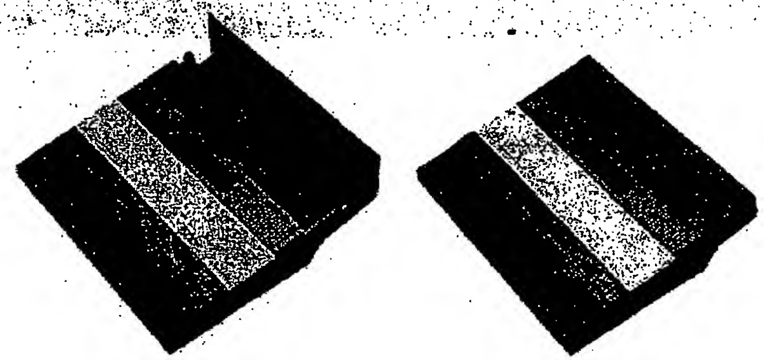


Controller Storage



When not in use, store the 5200 controllers inside the console unit as follows:
Unplug the 5200 controllers from the jacks on the front of the console.

Wind the controller cable around the joystick. Open the smoke-colored controller storage area at the top of the console.



Place the controllers face down (head-to-head) in the storage area.

Gently close the cover to the controller storage area.

6. Returning Your TV Set to Television Program Viewing

- Press the console POWER switch to OFF. The TV Antenna Switch Box automatically switches back to program viewing.
- If you turned off the automatic fine-tuning, turn it back on.

7. Maintaining Your ATARI 5200

Your ATARI 5200 will bring you many years of enjoyment. To keep it in good working condition, please remember the following:

- Always turn the POWER switch OFF when you are not using the ATARI 5200.
- Do not try to force the game cartridge into the cartridge slot.
- Take care not to spill liquids on the console, cartridges, or controllers.
- Do not lift the 5200 console or the 5200 controllers by the connecting wires. You could bend or crimp the wires and break the internal insulation.
- Be careful not to drop the console, controllers, or game cartridges on hard surfaces.
- Do not expose the console, controllers, or game cartridges to extreme or excessive heat.
- Do not use any power adapter other than the Power Adapter packed with your ATARI 5200. You could damage the electronic components in the console unit.
- Unplug the Power Adapter from the electrical outlet when it is not in use.
- Do not use any TV switch box other than the TV Antenna Switch Box packed with your ATARI 5200. You could damage the electronic components in the console unit.
- Clean the exterior surface of the console with a soft, slightly damp cloth (use water only).

NOTE: Your ATARI 5200 is engineered to eliminate phosphor memory or "burn in" of the playfield and score digits on your television screen. We suggest, however, these precautions:

- Turn down the contrast of your television set.
- Turn the ATARI 5200 OFF when not in use.

Compliance with FCC Regulations

To comply with Federal Communications Commission* (FCC) regulations and to keep your ATARI 5200 from interfering with television reception on nearby television sets, please observe the following:

- Do not install a longer antenna cable from the TV Antenna Switch Box to the antenna connection on your television set. The antenna cable supplied on the TV Antenna Switch Box is the right length and complies with FCC regulations.
- Do not connect the antenna output cable on your TV Switch Box directly to any television antenna or Cable TV outlet.
- Do not attach loose wires to your television antenna terminals when you are using the ATARI 5200.

* This equipment generates and uses radio frequency energy, and if it is not installed properly, it may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, try to correct the interference by one or more of the following methods:

- reorient the receiving antenna.
- relocate the computer with respect to the receiver.
- move the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, consult the dealer or an experienced radio/television technician for additional suggestions. You may find the following booklet prepared by the Federal Communications Commission helpful: "How to Identify and Resolve Radio-TV Interference Problems."

This booklet is available from the US Government Printing Office, Washington, DC 20402, Stock No. 004-000-00345-4.

8. Troubleshooting Checklist

The following list of symptoms, causes and remedies is supplied to help you troubleshoot any possible problems in setting up your ATARI 5200. Always disconnect the Power Adapter before checking any electrical connections.

Symptom	• ATARI logo and playfield image do not appear on the screen.
Probable Cause and Remedy	• Console POWER switch not ON. • Game cable not properly plugged into TV Antenna Switch Box. • Power jack not connected to the console. • Connection on 75 OHM television not functioning. Change to 300 OHM using the Switch Box Adapter. • TV Antenna Switch Box not correctly connected to television antenna. • Game cartridge not properly inserted. • Power Adapter not plugged into wall outlet. • Interference on Channel 3. Change console channel selector switch to ■ and change television channel selector to 2.
Symptom	• No regular television program viewing.
Probable Cause and Remedy	• Television antenna not correctly connected to TV Switch Box.

Symptom	• Game picture and playfield are fuzzy or the sounds are distorted.
Probable Cause and Remedy	• TV Antenna Switch Box not correctly connected to television antenna. • Television set not fine-tuned for the best picture. Make sure the automatic fine-tuning is off and manually fine-tune for the best picture. However, if your television receives color only when the fine-tuning is on, leave it on. • Interference on Channel 3. Change console channel selector switch to ■, and change television channel selector to 2.
Symptom	• No game sounds.
Probable Cause and Remedy	• Turn up the volume on your television set.

System Builder's Design Guide for Home Row's J-Mouse

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Clackamas, OR 97015
U.S.A.
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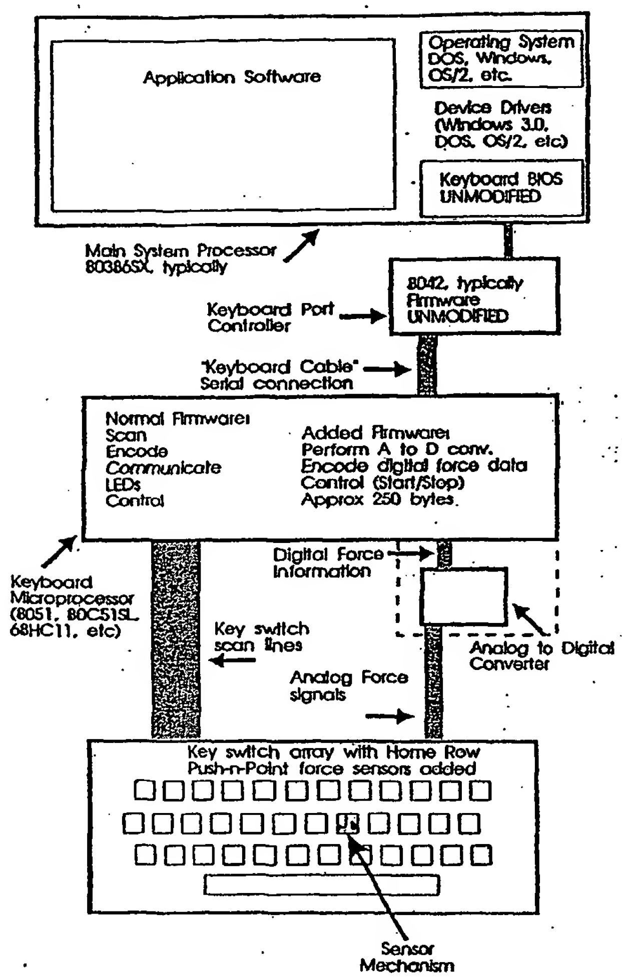
1. SCOPE - The purpose of this document is to provide sufficient information so that provisions may be made in the design of computer systems so that the J-Mouse may be easily incorporated into those systems either now or in the future. Actual implementation of the J-Mouse varies depending on the design and components of a particular computer system. While following these guidelines will result in the reduction of the amount and the extent of changes required to implement the J-Mouse at a later date, it does not guarantee that no changes will be required.

2. DESCRIPTION - The J-Mouse allows a computer user to move a screen cursor smoothly in any direction by pushing on the "J" key of the keyboard in whatever direction the cursor is desired to go. Pointing event buttons, or "mouse" buttons, are provided by other keys on the keyboard. The various elements of the Home Row Pointing Device technology are protected by patents issued and pending world wide.

   2.1. GENERAL: There are five basic elements of the J-Mouse in the design of a keyboard system; mechanical, electrical, firmware, keyboard port controller (8042) and device drivers. The J-Mouse Block Diagram, Figure 1, illustrates the relationship among these elements.

   2.2. SENSOR MECHANISM consists of some new parts and keyboard modifications that are required to provide for the transfer of forces from the keycap to the force sensor which then generate the electrical signal required to determine cursor movement. The elements of the Sensor Mechanism must be integrated into the design of a particular keyboard. This integration will require the modification of existing tooling and the fabrication of new tooling. Although the fundamental requirements of the Sensor Mechanism design are known and established, the actual details of the design and related modifications will vary depending on the keyboard that is to include the J-Mouse. As with all new designs, specific Sensor Mechanism implementations require thorough testing by licensee and/or OEM prior to release to production to insure proper operation, reliability and manufacturability.

   2.3. ANALOG TO DIGITAL (A/D) HARDWARE converts the signals from the Sensor Mechanism to digital form for the keyboard microprocessor. The requirements for the A/D are defined, but may be satisfied with a variety of circuit implementations each of which have certain advantages and disadvantages with respect to part cost, power consumption and physical space requirement. Depending upon the system into which the keyboard with the J-Mouse will be integrated, some of the required circuitry may already be present such as a keyboard microcontroller with on-board A/D. Therefore, the A/D design must be coordinated with the system design architecture and requirements to insure optimal implementation. As with all new designs, specific A/D hardware implementations require thorough testing by licensee and/or OEM prior to release to production to insure proper operation, reliability and manufacturability.



J-Mouse System Block Diagram
Figure 1

2.4. FIRMWARE is added to the keyboard microprocessor to read the A/D hardware and send the resulting values to the host computer. The specification for the new firmware to be added to the keyboard microprocessor is well defined, however actual coding is dependent upon the microprocessor used. Home Row has developed and tested code for a number of the more popular microprocessors. If a different microprocessor is used, new code will need to be generated. As with all new code, thorough testing by licensee and/or OEM prior to release to production is required to insure proper operation and reliability.

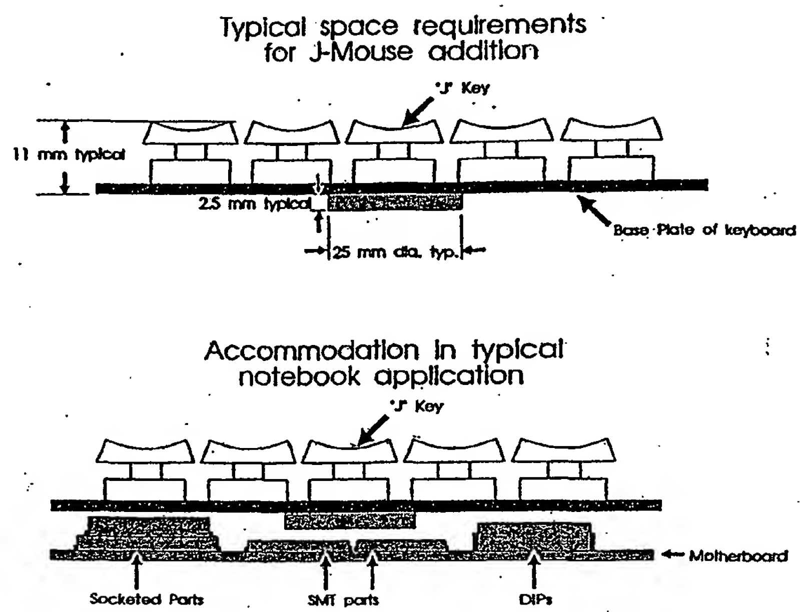
2.5. Keyboard Port Controller (8042) processes data from the keyboard and passes to the Host. No changes are required to the Keyboard Port Controller hardware or firmware.

2.6. DEVICE DRIVERS are loaded on the host computer and examine the keyboard data stream and use the key press/release information and the Sensor Mechanism data to emulate a mouse. This software is designed to operate with IBM PC AT and compatible equipment and has been thoroughly tested for proper operation and compatibility. Home Row is responsible for maintaining the operation and compatibility of the Driver Software on a continual basis. The driver does contain a "personality module section", see Figure 6, that provides default tracking parameters for the particular keyboard and identification information that may be required by the keyboard manufacturer and/or customer. The "personality" information is determined during testing phases and added to the driver for final verification testing. Thorough testing by licensee and/or OEM of the "personality" information prior to release to production is required to insure proper operation.

3. MECHANICAL - The mechanical allowances for the J-Mouse are the most numerous and specific in the design of the keyswitch array which is of little importance to the system builder as it is an OEM component. The key part of the mechanical implementation for the System Builder is the requirement of space for the preload spring beneath the "J" or pointing key. The clearance to be provided is a 0.984 inch (25 mm) diameter by 0.098 inch (2.5 mm) high envelope below the base plate of the keyboard. See Figure 2.

4. ELECTRICAL - The electrical element for the J-Mouse consists of two parts; electrical connection of the force sensor and analog to digital conversion of the force sensor signal.

4.1. FORCE SENSOR CONNECTION - The force sensor is a thick film device with five conductive silver ink pads for connection to support electronics. The five signal traces can be routed, per the system builder's specifications, to either a separate connector tail, added to an existing connector tail, a standard connector or other means whereby they may be connected to the analog to digital conversion circuitry.



J-Mouse Mechanism Space Requirements
Figure 2

4.2 ANALOG/DIGITAL CONVERSION - The J-Mouse force sensor provides an analog signal which must be digitized. This can be accomplished in a number of ways all of which have design trade offs of cost, component count and power consumption.

4.2.1. On-Chip 8-Bit Analog to Digital Converter, which requires the use of a keyboard controller that includes a built in A/D converter, is the simplest, most cost effective method using the least amount of board space. Another advantage is the few number of port bits needed to control the A/D conversion of the force sensor; only four A/D channels are needed.

Such CMOS based processors are: Motorola 68HC11; Signetics 80C552, 83C752, 83C550 and 83C562; Texas Instruments TMS370C350, TMS370C332, TMS370C352, and TMS370C356; NEC uPD78C11 and uPD78C14; and Intel 80C51GB and 80C51SL. Signetics and Intel parts are compatible with the 8051 (MCS-51) family of microcontrollers. If keyboard software has been written for this processor, then one of these controllers can be used and maintain code compatibility while just adding

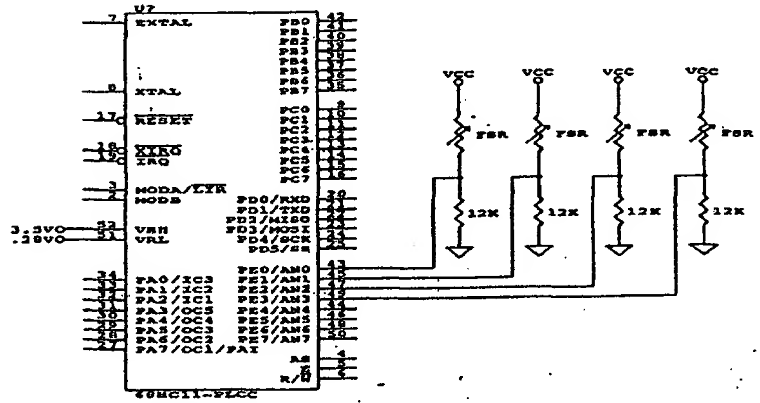
the code for the J-Mouse force sensor thus avoiding rewriting existing code for a new controller.

A simple voltage divider network is all that is necessary to capture force data from the force sensor. See Figure 3. The common connection from the force sensor should be connected to Vcc, a divider resistor is then connected from each force sensor grid lead to ground. A/D inputs are then connected to the intersection of the force sensor grid and it's associated divider resistor. If a microcontroller without built-in sample and hold is used, a 2.2uF capacitor should be connected across the divider resistor to limit susceptibility to A/D conversion errors due to a rapid voltage swing. The addition of this capacitor will also assist in protection from radiation from external sources (RFI).

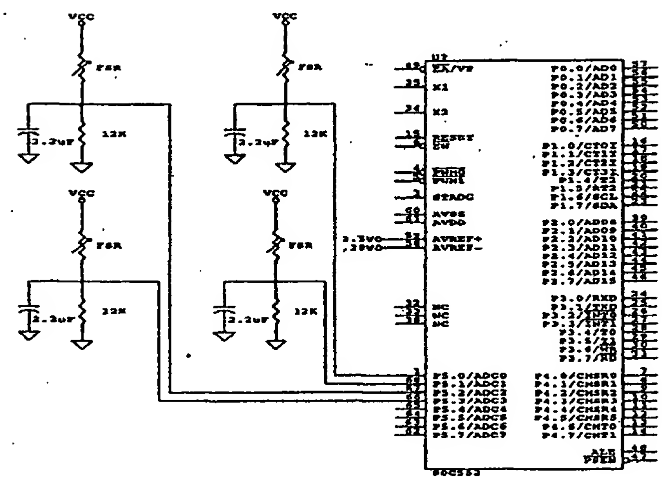
If a device is used with only one A/D channel available, some sort of multiplexing methodology will need to be incorporated. At least 2 port bits will be needed to select the force sensor to be scanned. When an external multiplexing design is used only a single divider resistor is needed for a single channel A/D channel. Some adjustment of the A/D voltage range may be necessary in order to achieve adequate sensitivity. This is only necessary for Vlow and is accomplished by adjusting the A/D range to swing between Vlow and Vcc. This will also eliminate a dead range between 0V and Vlow also improving A/D resolution.

4.2.2. External 8-Bit Analog to Digital Converters are widely available in many different packages and technologies. This method has the advantage of not having to use one of the more complex microcontrollers. The same 80C51 can be used but with roughly the same impact on software as the single chip solution with built-in A/D. Multiplexed 4 and 8 channel A/D converters exist that are easily connected to a microcontroller. This method requires more port bits to control it, especially if a parallel output device is used. Serial multi-channel devices also exist that can dramatically reduce the port bits needed.

The force sensor interface is, as before, straightforward and simple. A voltage divider circuit is all that is needed with a 2.2uF capacitor across the divider resistor to ground for A/D converters without built-in sample and hold. See Figure 4 for example circuits. As mentioned above, the A/D range should be adjusted to eliminate the dead range between 0V and Vlow. Single input A/D convertors will need to have some sort of multiplexing to accommodate the four force sensor grids . Possible devices that can be used are: National Semiconductor ADC0805, ADC0833, ADC0834, and ADC0844; Maxim MAX154; Linear Technologies LTC1099; and Texas Instruments TLC543, ADC0805 and ADC0834.



A/D conversion using Motorola 68HC11



A/D conversion using Signetics 80C552
Note: 80C552 does not have sample/hold

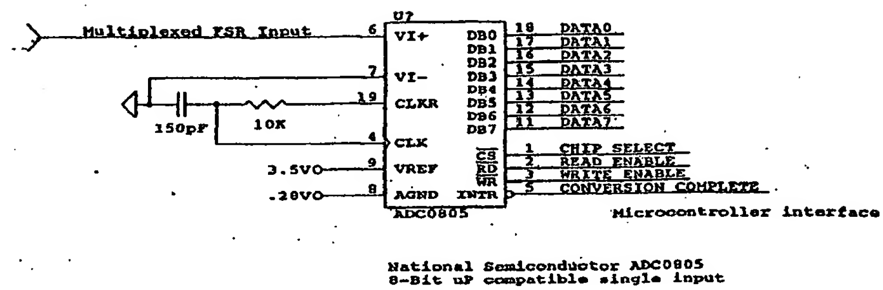
On Chip 8-Bit Analog/Digital Converter Examples
Figure 3

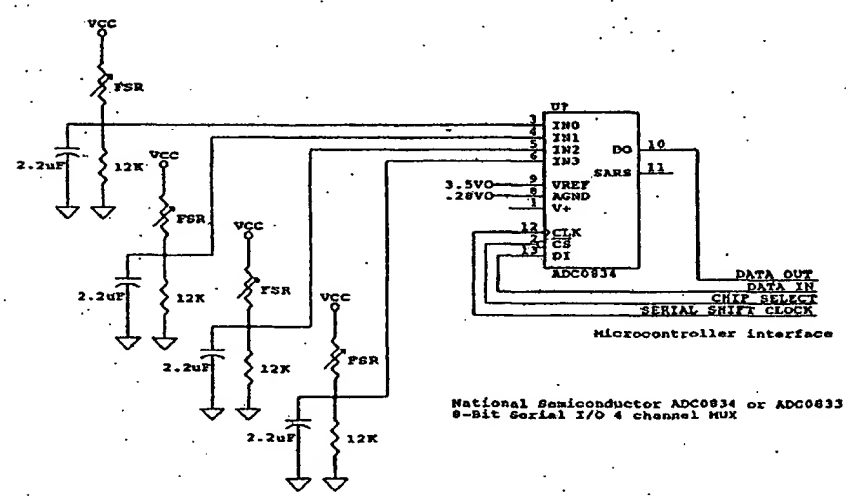
A large number of A/D converters exist and those listed represent a small sample. Depending on how many port bits can be utilized will determine which converter may used. If multiplexing keyboard scanning with decoders can be effectively done with the resulting number of port bits freed, any number of solutions can be designed in.

4.2.3. Charged Capacitor Conversion represents the simplest hardware interface at the cost of increased power consumption. See Figure 5. The force sensor common lead is connected to Vcc with the other four leads connected to a capacitor. The intersecting node between the capacitor and the force sensor is then connected to a True CMOS device input either on the microcontroller or external device (74C14). From a discharged state the capacitor is allowed to charge at a rate governed by the force sensor resistance. A software counter in the microcontroller is decremented while charging occurs. When the capacitor charges up to the CMOS high input threshold voltage, the microcontroller will stop it's counter and a value corresponding to the RC time constant produced by the resistor/capacitor network results. Another portion of the circuit allows the microcontroller to discharge the capacitor.

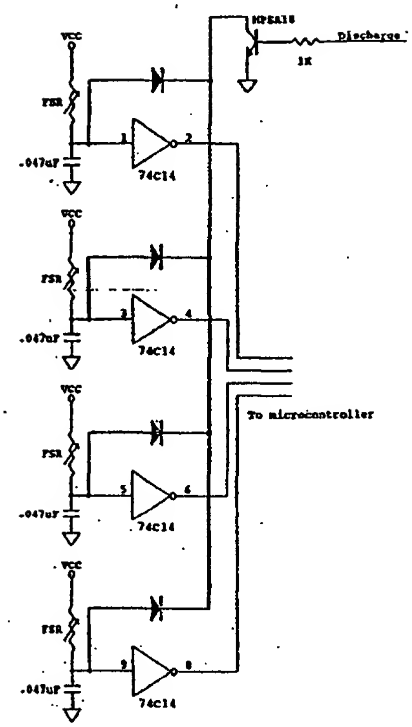
This technique provides for a relatively inexpensive conversion technique at a cost to the keyboard scanning rate. This is due to the fact that the microcontroller must continually sit in a loop and watch for the port bit to change. This MUST be uninterrupted time since any disturbance will cause an incorrect count. Keyboard scanning cannot be performed while measuring a force sensor nor can data be received from the PC as this also would influence the conversion count. At a maximum processor speed of 12MHz this can take as long as 5.1 ms to complete a conversion of four force sensor grids in a 2 instruction loop. Adding in the fact that the force sensor grids need to be scanned at a minimum rate of 15 scans (all four force sensor grids) per second results in about 77mSec for every second needed for force sensor scanning. This can become significant in keyboard scanning and can have a detrimental effect on keyboard performance. For slower clock rates, this becomes even more significant.

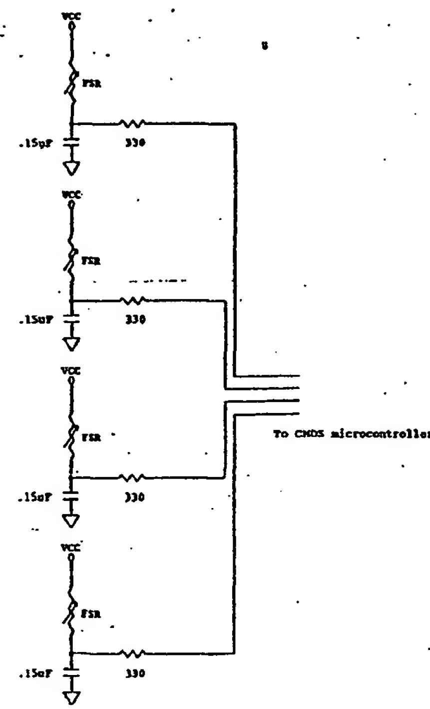
Five port bits at a minimum are required. One method of using one of the internal 8051 timers and it's external run control has been successfully implemented. However, most keyboard designs make use of both 8051 timers so this may not be a useful alternative. This method also needs to externally multiplex the four force sensor grids into the single timer input of the 8051. The charged capacitor method is not recommended by Home Row as it may impact keyboard response and power consumption for the four element sensor is estimated to be less than 2.0 milliwatts.





External 8-Bit Analog/Digital Converter Examples
Figure 4





Technique for scanning FSRs with a CMOS microcontroller
Setting the port bit to a "0" will discharge the cap.
Setting the port bit to a "1" will begin a charging period.

Technique for scanning FSRs for a NON CMOS microcontroller
Setting the discharge control to a "1" will discharge the caps.
Setting the discharge control to a "0" will begin a charging period.

Charged Capacitor Conversion Examples
Figure 5

5. **FIRMWARE** - Additional firmware is required in the keyboard microprocessor to encode the J-Mouse data for use by the Home Row Driver software resident in the host computer.

5.1. EXISTING KEYBOARD FIRMWARE - Typically, a keyboard for a PC compatible system has a keyboard microprocessor, usually an 8 bit micro like an Intel 8051. In a desktop environment, this micro is located physically in the keyboard itself, in a portable system it may be on the motherboard. In a PC compatible, the firmware in this micro performs the following tasks:

Scan the keyswitch array
Encode key press and key release information
Manage LEDs
Control functions like typematic (auto-repeat)
Manage serial communications to host

The firmware to perform these functions is typically written by keyboard manufacturers. Companies like Phoenix or SystemSoft, etc. may also provide this code.

5.2. J-MOUSE FIRMWARE - In order to add the J-Mouse functionality, the following functions need to be added:

5.2.1. Perform the analog to digital conversion of the force sensor data. The code needed to do this is about 80 bytes whether a capacitor-charging A-D or a microprocessor with built-in A-D, as in Intel 80C51SL or Motorola 68HC11, is used.

5.2.2. Encode the digitized force data information according to the Home Row specification. This requires about 100 to 300 bytes.

5.2.3. Control functions like start/stop digitizing and encoding which requires about 60 bytes.

Home Row provides detailed specifications and sample source code, for Intel 8051-class and Motorola 68HC11-class processors, for these functions described in sections 5.2.1. The sample source code may be obtained from Home Row licensed keyboard manufacturers, or directly from Home Row. There is no charge for this code, nor any royalty charged for its use.

6. **KEYBOARD PORT CONTROLLER (8042)** - The J-Mouse system is fully compatible with standard PC keyboard port controller. On normal PC-compatible systems, no change is needed to the keyboard port controller, normally an 8042. This is possible because the pointing information is encoded so that it is passed through the keyboard port controller system unmodified.

7. **DEVICE DRIVERS** - The J-Mouse is tightly coupled with the keyboard system, therefore device drivers are necessary to make the system compatible with applications software written to use a mouse. These device drivers are fully compatible with mouse drivers at a software level. It is not possible to make the J-Mouse system hardware compatible with a mouse; therefore Microsoft mouse drivers cannot be used. The J-Mouse drivers are supplied to the end user both on the system hard disk and on separate system floppy disks. Figure 10 illustrates the J-Mouse driver architecture. Their installation is simple and well documented.

7.1. DOS - Five years ago, it was common for each application program to have its own device driver for each pointing device. This was because at that time DOS had no standard software interface for mouse/pointing device. Most mice were serial devices, but at that time the penetration pointing devices in the PC compatible market was low: about 10%.

Since that time, several important changes have happened. Microsoft has defined a standard software interface to mouse functions, which uses interrupt 33. This interface is implemented by a device driver, typically referred to as MOUSE.SYS or MOUSE.COM. The .SYS and .COM versions are essentially identical; they differ in how they are installed. The .SYS version is installed in the CONFIG.SYS file; and is a true DOS device driver. The .COM version is usually installed in the AUTOEXEC.BAT file, and is technically a TSR.

Several years ago this device driver interface began to become popular. It was first seen when Microsoft introduced the "IMPORT" Bus mouse. Since this hardware interface is not compatible with the serial interface, many application programs which had device drivers for Microsoft (serial) mice would not work with the new "Bus" mouse. At that time it was typical for each application program to be shipped with a set of device drivers and instructions for the user to install one. With the advent of the bus mouse, most application software builders responded by building a new device driver - one that did not "talk" to hardware at all, but "talked" to another device driver, the MOUSE.COM/MOUSE.SYS driver via the INT 33 software interface.

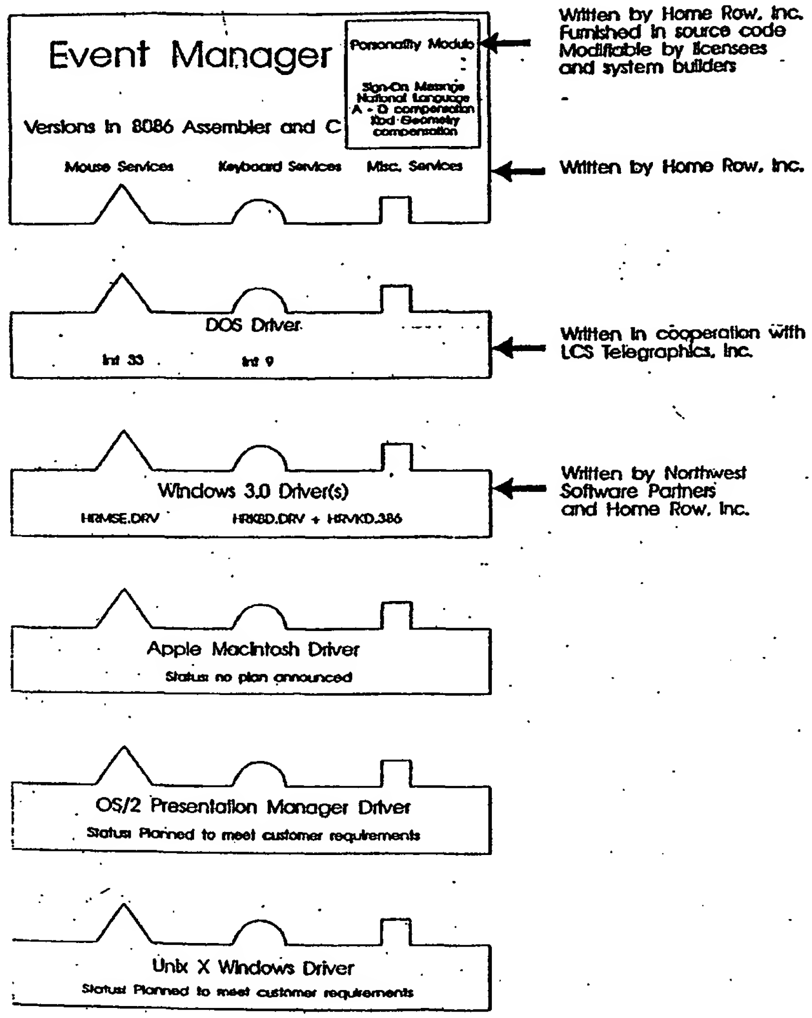
Today, some DOS mouse-aware software that is newer versions of older mouse-aware software still has its own device driver structure. In this software, users are usually urged to select "Microsoft Bus Mouse" from the choices for device drivers, even if they are using a Microsoft Serial mouse. This leads to some confusion, because what they are really selecting is to use the new INT 33 software mouse standard. Examples of this type of software include PC Paintbrush, AutoCAD, and Microsoft Word.

Two years ago, Microsoft published a book called the *Microsoft Mouse Programmer's Reference*. The book is accompanied by a disk with example software. This book defines the INT 33 programming interface to the standard. New DOS (Non-Windows) software that is mouse-aware is invariably written to the INT 33 software standard. Examples include Quattro Pro, PC Tools Deluxe, DAC Easy accounting. The Home Row J-Mouse DOS driver is fully compatible with the

Microsoft Mouse driver at the software interface INT 33h level. The J-Mouse DOS driver uses 17.5 Kb of memory when loaded.

- The Home Row DOS driver has been tested with a wide range of DOS Mouse-compatible application software including, but not limited to:

AutoCAD
AutoDesk
Animator
AutoShade
AutoSketch
Battle Chess
CADKEY
CadPlan
CADvance
Click Art Personal
Publisher
Codeview
Cribbage/Gin
DAC Easy
Accounting
Direct Access
DO-IT
Dr. Halo
Drafix
Draw Applause
DRI GEM
Graphics:
Ventura Publisher
Artline
Gem Draw
Gem Publisher
Perfill/Perform
EGA Paint
Express Publisher
Fastback
Fontrix
Freelance
Generic CADD
Harvard Graphics
IBM Storyboard
Interleave
IPRINT
Lotus 123 (recent
versions with
mouse support)
Microsoft Word
Microsoft Works
Norton Editor
ORCAD
Paradox
PC Paint
PC Paintbrush
PC Tools
PC Tools Deluxe
PFS First Publisher
ProCAD
Quattro Pro
Quick Basic
Quick C
Ready!
Reflex
RoboCAD-PC
EnerGraphics
Show Partner
Smartwork
Splash!
TelePaint
TeleVision
Tempra
TIPS
TIPS Graphics
software
VersaCAD
Where in the XXX
is Carmen Sandiego
Word Perfect 5.1
Xact



J-Mouse Driver Architecture
Figure 6

7.2. MICROSOFT WINDOWS - Windows is, by design, a true device-independent graphics system. It has well-defined software that interfaces for both display and input. All Windows application software is required to conform to and use the Windows mouse device driver software interface. All Windows software is strongly encouraged to conform to IBM's System Application Architecture Common User Interface standard (SAA/CUI). A copy of the book defining this standard is included in each Windows Software Development Kit (SDK). The SAA/CUI standard defines standard actions which should always perform common actions: Shift-Click extends a region of selected text, double click selects a word, and well-defined functions perform CUT, COPY, PASTE, UNDO, and Delete functions.

Home Row provides a Windows 3.0 device driver that meets the Windows mouse device driver software interface. It provides supplemental mouse buttons to take advantage of SAA/CUI. These include common Windows functions as cut, copy, paste, undo, double click, shift click, escape as well as normal three mouse button support.

We have tested the Home Row Windows 3.0 device driver with the following:

All of the software included in Windows (Paint, Write, Solitare, etc.)
Ventura Publisher for Windows
Corel Draw
WinFax
Delrina's Perform/Perfill
Windows Entertainment Pack
MATHCAD for Windows
Microsoft Word for Windows
Microsoft Excel 2.0
Microsoft PowerPoint
Home Will Kit
BitStream FaceLift
Hdc First Apps

7.3. UNIX / X WINDOWS - The Unix / X windows market is primarily implemented on engineering workstations. The first portable systems are just being designed. As portable systems become more popular, a need for keyboard-integrated pointing devices will become more apparent. Home Row has plans to implement Unix drivers for the J-Mouse as needed by our customers. Unix X windows is a device-independent environment like Microsoft Windows and therefore no technical difficulties are anticipated.

7.4. OTHER - Home Row will develop other drivers as required by our customers.

8. SCHEDULE - The purpose of this section is to communicate the process of implementing the Home Row Pointing Device Technology, J-Mouse, into a computer system. The most significant determining factor in the schedule is whether the selected keyboard vendor has licensed the Home Row technology. The time required to negotiate a license agreement and accomplish the transfer of technology with a new licensee can be several months. Also, a current licensee will have experience with Home Row technology which will result in the minimum leadtime.

It is important to note that although the J-Mouse may be implemented in a keyboard in current production, the integration into a different model keyboard may require a new mechanical and hardware design. Typically new systems require a custom keyboard layout which results in new tooling and the accompanying leadtime. The strategy and schedule outlined below include the transfer of technology process; the license negotiating process is not included as estimation of duration is quite difficult. If a currently licensed keyboard vendor is used, then process would start at step 3, OEM specifies keyboard configuration and keyboard controller implementation.

8.1. IMPLEMENTATION STRATEGY - Strategy consists of several steps which are typical with those used in the development of a new product. Although the basic design elements of the J-Mouse have been proven in a variety of implementations, each new application of the Home Row technology represents the development of a new product. Clearly, the more similar a new application is to one in current production, the less rigorous and therefore time consuming the development needs to be.

8.1.1. License Agreement is signed by Home Row and Licensee (and approved by governmental agencies as required)

8.1.2. Home Row makes Technology Transfer Presentation and conveys reference documentation to licensee which includes specifications, User Guide and Reference Manual.

8.1.3. OEM specifies keyboard configuration and keyboard controller implementation. System architecture and basic requirements such as cost, power consumption and physical space are also identified and specified.

8.1.4. A/D approach is selected which is compatible with planned hardware and system requirements.

8.1.5. Sensor Mechanical design concept is developed, or selected, for keyboard.

8.1.6. Build prototype with Sensor Mechanism and A/D per specification.

8.1.7. Code and compile keyboard controller firmware with additional the J-Mouse capability. If a keyboard controller chipset which supports J-Mouse is used, then firmware and A/D circuitry is provided by the chipset supplier.

8.1.8. Test prototype and characterize performance to develop personality parameters. At most 2 iterations will be required to achieve required results.

8.1.9. Build Pre-production units using production tooling, manufacturing test and assembly procedures to verify performance and reliability.

8.1.10. Evaluation and characterization of pre-production units by Home Row to determine acceptability of conformance to pointing quality standards.

8.1.11. Identify and implement final updates/corrections to designs, tools and documentation.

8.1.12. Start production.

8.1.13. Home Row provides ongoing compatibility and enhancement support of standard host driver software.

8.2. INTEGRATION & TEST - Home Row has software tools that exercise the keyboard firmware and A/D to verify settings and proper operation of sensors. These tools are described in detail in the Reference Manual. Source code will be provided for all these tools.

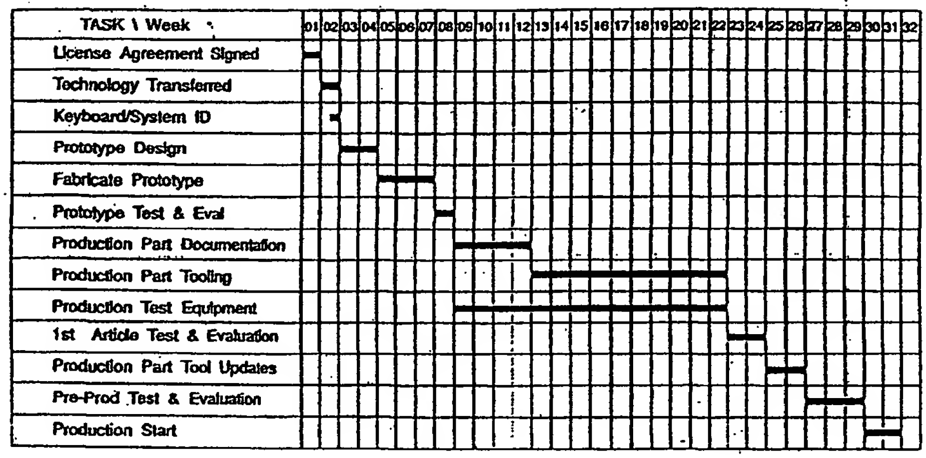
8.3. DOCUMENTATION - Home Row provides reference documentation and a User's Guide. The reference documents are provided to insure the proper implementation of the J-Mouse. A User's Guide, provided in camera ready or electronic file format, is available for use as is or can edited by and at the discretion of the licensee and/or OEM. The Reference Guide describes the software tools provided by Home Row.

8.4. SCHEDULE - Key milestone schedule for implementation of the J-Mouse is as follows with assumptions noted. Actual schedule may vary due to Licensee's and/or OEM's resource availability and capability. See Figure 7 for Gantt Chart of schedule.

Milestone	Complete (Week #)
License Agreement Signed and Approved	1
Technology Transfer Presentation	2
Keyboard & Controller Specified	2
Prototype Design Developed & Documented	4
Fabrication of Prototype Parts	7
Prototype Test & Evaluation (1st iteration)	8
Production Part Documentation	12
Production Part Tooling	22
Production Test Parts & Equipment	22
First Article Unit Test & Evaluation	24
Production Part Tooling Updates	26
Pre-Production Unit Test & Evaluation	29
Production Start	31

Assumptions:

Fabrication of prototype parts, electrical and mechanical, requires 3 weeks.
Fabrication of production part tooling, electrical and mechanical, requires 8 and 10 weeks respectively.
Updates to production tooling, electrical and mechanical, require 1 week.



Gantt Chart for J-Mouse Implementation Schedule
Figure 7

9. **FUTURE PHASES** - As previously indicated, although the J-Mouse may be implemented in a particular keyboard in current production, the integration into a different model keyboard may require a new mechanical and/or electrical design. It is the intention of Home Row to provide the support necessary to be successful with this new technology. It is important to involve Home Row in the planning stages of new the J-Mouse equipped keyboard projects so that support, when and if needed, can be provided in a timely manner.

Issues and Techniques in Touch-Sensitive Tablet Input

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Abstract

Touch-sensitive tablets and their use in human-computer interaction are discussed. It is shown that such devices have some important properties that differentiate them from other input devices (such as mice and joysticks). The analysis serves two purposes: (1) it sheds light on touch tablets, and (2) it demonstrates how other devices might be approached. Three specific distinctions between touch tablets and one button mice are drawn. These concern the signaling of events, multiple point sensing and the use of templates. These distinctions are reinforced, and possible uses of touch tablets are illustrated, in an example application. Potential enhancements to touch tablets and other input devices are discussed, as are some inherent problems. The paper concludes with recommendations for future work.

CR Categories and Subject Descriptors: I.3.1 [**Computer Graphics**]: Hardware Architecture: Input Devices. I.3.6 [**Computer Graphics**]: Methodology and Techniques: Device Independence, Ergonomics, Interaction Techniques.

General Terms: Design, Human Factors.

Additional Keywords and Phrases: touch sensitive input devices.

1. Introduction

Increasingly, research in human-computer interaction is focusing on problems of input [Foley, Wallace & Chan 1984; Buxton 1983; Buxton 1985]. Much of this attention is directed towards input technologies. The ubiquitous Sholes keyboard is being replaced and/or complemented by alternative technologies. For example, a major focus of the marketing strategy for two recent personal computers, the Apple Macintosh and Hewlett-Packard 150, has been on the input devices that they employ (the mouse and touch-screen, respectively).

Now that the range of available devices is expanding, how does one select the best technology for a particular application? And once a technology is chosen, how can it be used most effectively? These questions are important, for as Buxton [1983] has argued, the ways in which the user *physically* interacts with an input device have a marked effect on the type of user interface that can be effectively supported.

In the general sense, the objective of this paper is to help in the selection process and assist in effective use of a specific class of devices. Our approach is to investigate a specific class of devices: touch-sensitive tablets. We will identify touch tablets, enumerate their important properties, and compare them to a more common input device, the mouse. We then go on to give examples of transactions where touch tablets can be used effectively. There are two intended benefits for this approach. First, the reader will acquire an understanding of touch tablet issues. Second, the reader will have a concrete example of how the technology can be investigated, and can utilize the approach as a model for investigating other classes of devices.

2. Touch-Sensitive Tablets

A touch-sensitive tablet (touch tablet for short) is a flat surface, usually mounted horizontally or nearly horizontally, that can sense the location of a finger pressing on it. That is, it is a tablet that can sense that it is being touched, and where it is being

touched. Touch tablets can vary greatly in size, from a few inches on a side to several feet on a side. The most critical requirement is that the user is not required point with some manually held device such as a stylus or puck.

What we have described in the previous paragraph is a *simple* touch tablet. Only one point of contact is sensed, and then only in a binary, touch/no touch, mode. One way to extend the potential of a simple touch tablet is to sense the degree, or pressure, of contact. Another is to sense multiple points of contact. In this case, the location (and possibly pressure) of several points of contact would be reported. Most tablets currently on the market are of the "simple" variety. However, Lee, Buxton and Smith [1985], and Nakatani [private communication] have developed prototypes of multi-touch, multi-pressure sensing tablets.

We wish to stress that we will restrict our discussion of touch technologies to touch tablets, which can and should be used in ways that are different from touch screens. Readers interested in touch-screen technology are referred to Herot & Weinsapfel [1978], Nakatani & Rohrlich [1983] and Minsky [1984]. We acknowledge that a flat touch screen mounted horizontally is a touch tablet as defined above. This is not a contradiction, as a touch screen has exactly the properties of touch tablets we describe below, as long as there is no attempt to mount a display below (or behind) it or to make it the center of the user's visual focus.

Some sources of touch tablets are listed in Appendix A.

3. Properties of Touch-Sensitive Tablets

Asking "Which input device is best?" is much like asking "How long should a piece of string be?" The answer to both is: it depends on what you want to use it for. With input devices, however, we are limited in our understanding of the relationship between device properties and the demands of a specific application. We will investigate touch tablets from the perspective of improving our understanding of this relationship. Our claim is that other technologies warrant similar, or even more detailed, investigation.

Touch tablets have a number of properties that distinguish them from other devices:

- They have no mechanical intermediate device (such as stylus or puck). Hence they are useful in hostile environments (e.g., classrooms, public access terminals) where such intermediate devices can get lost, stolen, or damaged.
- Having no puck to slide or get bumped, the tracking symbol "stays put" once placed, thus making them well suited for pointing tasks in environments subject to vibration or motion (e.g., factories, cockpits).
- They present no mechanical or kinesthetic restrictions on our ability to indicate more than one point at a time. That is, we can use two hands or more than one finger simultaneously on a single tablet. (Remember, we can manually control at most two mice at a time: one in each hand. Given that we have ten fingers, it is conceivable that we may wish to indicate more than two points simultaneously. An example of such an application appears below).
- Unlike joysticks and trackballs, they have a very low profile and can be integrated into other equipment such as desks and low-profile keyboards (e.g., the Key Tronic Touch Pad, see Appendix A). This has potential benefits in portable systems, and, according to the Keystroke model of Card, Newell and Moran [1980], reduces homing time from the keyboard to the pointing device.
- They can be molded into one-piece constructions thus eliminating cracks and grooves where dirt can collect. This makes them well suited for very clean environments (eg. hospitals) or very dirty ones (eg., factories).
- Their simple construction, with no moving parts, leads to reliable and long-lived operation, making them suitable for environments where they will be subjected to intense use or where reliability is critical.

They do, of course, have some inherent disadvantages, which will be discussed at the close of the paper.

In the next section we will make three important distinctions between touch tablets and mice. These are:

- Mice and touch tablets vary in the number and types of events that they can transmit. The difference is especially pronounced when comparing to simple touch tablets.
- Touch tablets can be made that can sense multiple points of contact. There is no analogous property for mice.
- The surface of a tablet can be partitioned into regions representing a collection of independent "virtual" devices. This is analogous to the partitioning of a screen into "windows" or virtual displays. Mice, and other devices that transmit "relative change" information, do not lend themselves to this mode of interaction without consuming display real estate for visual feedback. With conventional tablets and touch tablets, graphical, physical or virtual templates can be placed over the input device to delimit regions. This allows valuable screen real estate to be preserved. Physical templates, when combined with touch sensing, permit the operator to sense the regions without diverting the eyes from the primary display during visually demanding tasks.

After these properties are discussed, a simple finger painting program is used to illustrate them in the context of a concrete example. We wish to stress that we do not pretend that the program represents a viable paint program or an optimal interface. It is simply a vehicle to illustrate a variety of transactions in an easily understandable context.

Finally, we discuss improvements that must be made to current touch tablet technology, many of which we have demonstrated in prototype form. Also, we suggest potential improvements to other devices, motivated by our experience with touch technology.

4. Three Distinctions Between Touch Tablets and Mice[1]

The distinctions we make in this section have to do with suitability of devices for certain tasks or use in certain configurations. We are only interested in showing that there are some uses for which touch tablets are not suitable, but other devices are, and vice versa. We make no quantitative claims or comparisons regarding performance.

Signaling

Consider a rubber-band line drawing task with a one button mouse. The user would first position the tracking symbol at the desired starting point of the line by moving the mouse with the button released. The button would then be depressed, to signal the start of the line, and the user would manipulate the line by moving the mouse until the desired length and orientation was achieved. The completion of the line could then be signaled by releasing the button.[2]

Figure 1 is a state diagram that represents this interface. Notice that the button press and release are used to signal the beginning and end of the rubber-band drawing task. Also note that in states 1 and 2 both motion and signaling (by pressing or releasing the button, as appropriate) are possible.

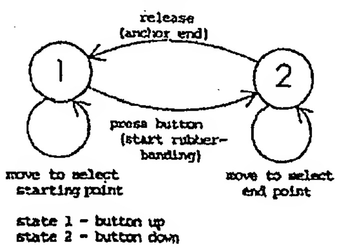

Figure 1. State diagram for rubber-banding with a one-button mouse.

Now consider a simple touch tablet. It can be used to position the tracking symbol at the starting point of the line, but it cannot generate the signal needed to initiate rubber-banding. Figure 2 is a state diagram representation of the capabilities of a simple touch tablet. In state 0, there is no contact with the tablet.[3] In this state only one action is possible: the user may touch the tablet. This causes a change to state 1. In state 1, the user is pressing on the tablet, and as a consequence position reports are sent to the host. There is no way to signal a change to some other state, other than to release (assuming the exclusion of temporal or spatial cues, which tend to be clumsy and difficult to learn). This returns the system to state 0. This signal could not be used to initiate rubber-banding, as it could also mean that the user is pausing to think, or wishes to initiate some other activity.

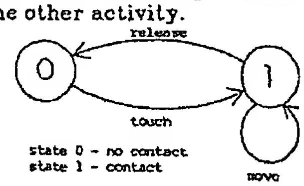

Figure 2. Diagram for showing states of simple touch-tablet.

This inability to signal while pointing is a severe limitation with current touch tablets, that is, tablets that do not report pressure in addition to location. (It is also a property of trackballs, and joysticks without "fire" buttons). It renders them unsuitable for use in many common interaction techniques for which mice are well adapted (e.g., selecting and dragging objects into position, rubber-band line drawing, and pop-up menu selection); techniques that are especially characteristic of interfaces based on *Direct Manipulation* [Shneiderman 1983].

One solution to the problem is to use a separate function button on the keyboard. However, this usually means two-handed input where one could do, or, awkward co-ordination in controlling the button and pointing device with a single hand. An alternative solution when using a touch tablet is to provide some level of pressure sensing. For example, if the tablet could report two levels of contact pressure (i.e., hard and soft), then the transition from soft to hard pressure, and vice versa, could be used for signaling. In effect, pressing hard is equivalent to pressing the button on the mouse. The state diagram showing the rubber-band line drawing task with this form of touch tablet is shown in Figure 3.[4]

As an aside, using this pressure sensing scheme would permit us to select options from a menu, or

[1] Although we are comparing touch tablets to one button mice throughout this section, most of the comments apply equally to tablets with one-button pucks or (with some caveats) tablets with styli.

[2] This assumes that the interface is designed so that the button is held down during drawing. Alternatively, the button can be released during drawing, and pressed again, to signal the completion of the line.

[3] We use state 0 to represent a state in which no location information is transmitted. There no analogous state for mice, and hence no state 0 in the diagrams for mice. With conventional tablets, this corresponds to "out of range" state.

At this point the alert reader will wonder about difficulty in distinguishing between hard and soft pressure, and friction (especially when pressing hard). Taking the last first, hard is a relative term. In practice friction need not be a problem (see Inherent Problems, below).

[4] One would conjecture that in the absence of button clicks or other feedback, pressure would be difficult to regulate accurately. We have found two levels of pressure to be easily distinguished, but this is a ripe area for research. For example, Stu Card [private communication] has suggested that the threshold between soft and hard should be reduced (become "softer") while hard pressure is being maintained. This suggestion, and others, warrant formal experimentation.

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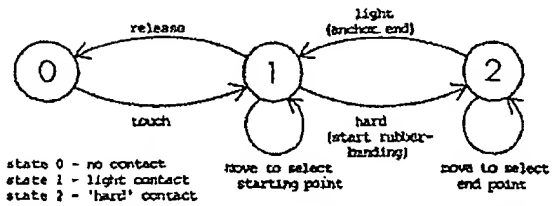

Figure 3. State diagram for rubber-banding with pressure sensing touch tablet.

activate light buttons by positioning the tracking symbol over the item and "pushing". This is consistent with the gesture used with a mouse, and the model of "pushing" buttons. With current simple touch tablets, one does just the opposite: position over the item and then lift off, or "pull" the button.

From the perspective of the signals sent to the host computer, this touch tablet is capable of duplicating the behaviour of a one-button mouse. This is not to say that these devices are equivalent or interchangeable. They are not. They are physically and kinesthetically very different, and should be used in ways that make use of the unique properties of each. Furthermore, such a touch tablet can generate one pair of signals that the one-button mouse cannot — specifically, press and release (transition to and from state 0 in the above diagrams). These signals (which are also available with many conventional tablets) are very useful in implementing certain types of transactions, such as those based on character recognition.

An obvious extension of the pressure sensing concept is to allow continuous pressure sensing. That is, pressure sensing where some large number of different levels of pressure may be reported. This extends the capability of the touch tablet beyond that of a traditional one button mouse. An example of the use of this feature is presented below.

Multiple Position Sensing

With a traditional mouse or tablet, only one position can be reported per device. One can imagine using two mice or possibly two transducers on a tablet, but this increases costs, and two is the practical limit on the number of mice or tablets that can be operated by a single user (without using feet). However, while we have only two hands, we have ten fingers. As playing the piano illustrates, there are some contexts where we might want to use several, or even all of them, at once.

Touch tablets need not restrict us in this regard. Given a large enough surface of the appropriate technology, one could use all fingers of both hands simultaneously, thus providing ten separate units of input. Clearly, this is well beyond the demands of many applications and the capacity of many people, however, there are exceptions. Examples include chording on buttons or switches, operating a set of slide potentiometers, and simple key roll-over when touch typing. One example (using a set of slide potentiometers) will be illustrated below.

Multiple Virtual Devices and Templates

The power of modern graphics displays has been enhanced by partitioning one physical display into a number of virtual displays. To support this, display window managers have been developed. We claim (see Brown, Buxton and Murtagh [1985]) that similar benefits can be gained by developing an input window manager that permits a single physical input device to be partitioned into a number of virtual input devices. Furthermore, we claim that multi-touch tablets are well suited to supporting this approach.

Figure 4a shows a thick cardboard sheet that has holes cut in specific places. When it is placed over a touch tablet as shown in Figure 4b, the user is restricted to touching only certain parts of the tablet. More importantly, the user can *feel* the parts that are touchable, and their shape. Each of the "touchable" regions represents a separate virtual device. The distinction between this template and traditional tablet mounted menus (such as seen in many CAD systems) is important.

Traditionally, the options have been:

a) Save display real estate by mounting the menu on the tablet surface. The cost of this option is eye diversion from the display to the tablet, the inability to "touch type", and time consuming menu changes.

b) Avoid eye diversion by placing the menus on the display. This also make it easier to change menus, but still does not allow "touch typing", and consumes display space.

Touch tablets allow a new option:

c) Save display space and avoid eye diversion by using templates that can be felt, and hence, allow "touch typing" on a variety of virtual input devices. The cost of this option is time consuming menu (template) changes.

It must be remembered that for each of these options, there is an application for which it is best. We have contributed a new option, which makes possible new interfaces. The new possibilities include more elaborate virtual devices because the improved kinesthetic feedback allows the user to concentrate on providing input, instead of staying in the assigned region. We will also show (below) that its main cost (time consuming menu changes) can be reduced in some applications by eliminating the templates.

5. Examples of Transactions Where Touch Tablets Can Be Used Effectively

In order to reinforce the distinctions discussed in the previous section, and to demonstrate the use of touch tablets, we will now work through some examples based on a toy paint system. We wish to stress again that we make no claims about the quality of the example as a paint system. A paint system is a common and easily understood application, and thus, we have chosen to use it simply as a vehicle for discussing interaction techniques that use touch tablets.

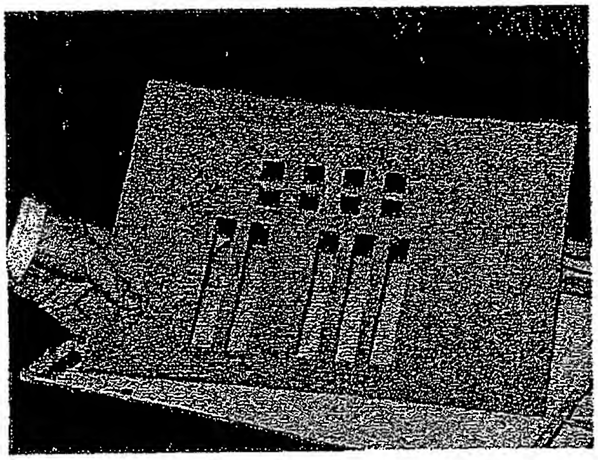

Figure 4a. Sample template.

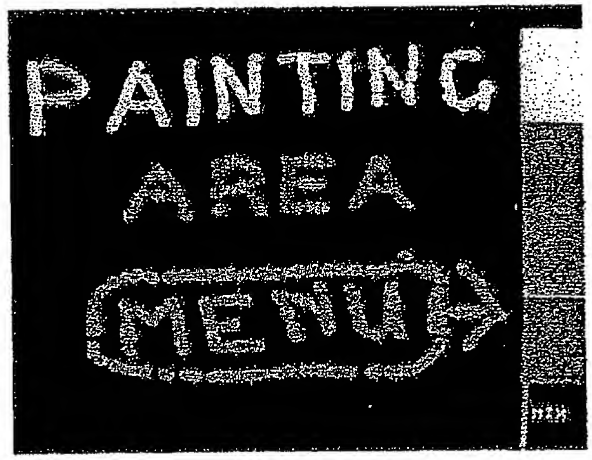

Figure 5. Main display for paint program.

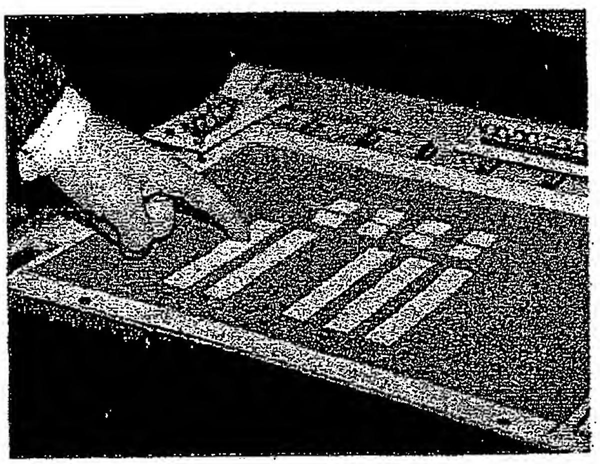

Figure 4b. Sample template in use.

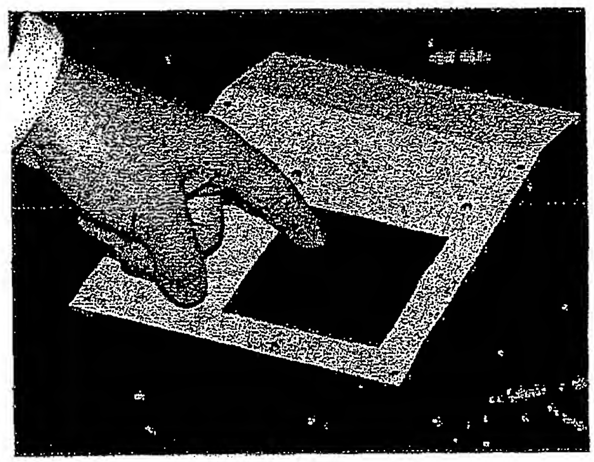

Figure 6. Touch tablet used in demonstrations.

The example paint program allows the creation of simple finger paintings. The layout of the main display for the program is shown in Figure 5. On the left is a large drawing area where the user can draw simple free-hand figures. On the right is a set of menu items. When the lowest item is selected, the user enters a colour mixing mode. In switching to this mode, the user is presented with a different display that is discussed below. The remaining menu items are "paint pots". They are used to select the colour that the user will be painting with.

In each of the following versions of the program, the input requirements are slightly different. In all cases an 8 cm x 8 cm touch tablet is used (Figure 6), but the pressure sensing requirements vary. These are noted in each demonstration.

5.1. Painting Without Pressure Sensing

This version of the paint program illustrates the limitation of having no pressure sensing. Consider the paint program described above, where the only input device is a touch tablet without pressure sensing. Menu selections could be made by pressing down somewhere in the menu area, moving the tracking symbol to the desired menu item and then selecting by releasing. To paint, the user would simply press down in the drawing area and move (see Figure 7 for a representation of the signals used for painting with this program).

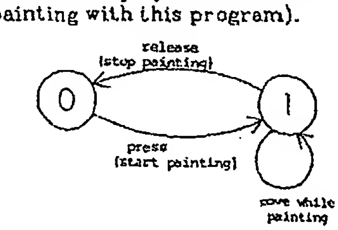

Figure 7. State diagram for drawing portion of simple paint program.

There are several problems with this program. The most obvious is in trying to do detailed drawings. The user does not know where the paint will appear until it appears. This is likely to be too late. Some form of feedback, that shows the user where the brush is, without painting, is needed. Unfortunately, this cannot be done with this input device, as it is not possible to signal the change from tracking to painting and vice versa.

The simplest solution to this problem is to use a button (e.g., a function key on the keyboard) to signal state changes. The problem with this solution is the need to use two hands on two different devices to do one task. This is awkward and requires practice to develop the co-ordination needed to make small rapid strokes in the painting. It is also inefficient in its use of two hands where one could (and normally should) do.

Alternatively, approaches using multiple taps or timing cues for signalling could be tried, however, we have found that these invariably lead to other problems. It is better to find a direct solution using the properties of the device itself.

5.2. Painting with Two Levels of Pressure

This version of the program uses a tablet that reports two levels of contact pressure to provide a satisfactory solution to the signaling problem. A low pressure level (a light touch by the user) is used for general tracking. A heavier touch is used to make menu selections, or to enable painting (see Figure 8 for the tablet states used to control painting with this program). The two levels of contact pressure allow us to make a simple but practical one finger paint program.

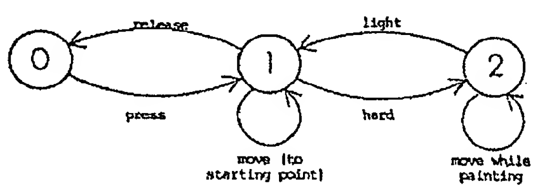

Figure 8. State diagram for painting portion of simple paint program using pressure sensing touch tablet.

This version is very much like using the one button mouse on the Apple Macintosh with MacPaint [Williams, 1984]. Thus, a simple touch tablet is not very useful, but one that reports two levels of pressure is similar in power (but not feel or applicability) to a one button mouse.[5]

5.3. Painting with Continuous Pressure Sensing

In the previous demonstrations, we have only implemented interaction techniques that are common using existing technology. We now introduce a technique that provides functionality beyond that obtainable using most conventional input technologies.

In this technique, we utilize a tablet capable of sensing a continuous range of touch pressure. With this additional signal, the user can control both the width of the paint trail and its path, using only one finger. The new signal, pressure, is used to control width. This is a technique that cannot be used with any mouse that we are aware of, and to our knowledge, is available on only one conventional tablet (the GTCO Digipad with pressure pen [GTCO 1982]).

We have found that using current pressure sensing tablets, the user can accurately supply two to three bits of pressure information, after about 15 minutes practice. This is sufficient for simple doodling and many other applications, but improved pressure resolution is required for high quality painting.

5.4. "Windows" on the Tablet: Colour Selection

We now demonstrate how the surface of the touch tablet can be *dynamically* partitioned into "windows" onto virtual input devices. We use the same basic techniques as discussed under templates (above), but show how to use them without templates. We do this in the context of a colour selection module for our paint program. This module introduces a new display, shown in Figure 9.

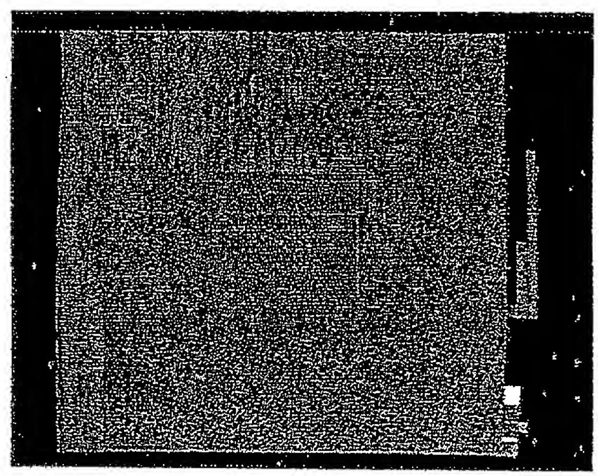

Figure 9. Colour mixing display.

In this display, the large left side consists of a colour patch surrounded by a neutral grey border. This is the patch of colour the user is working on. The right side of the display contains three bar graphs with two light buttons underneath. The primary function of the bar graphs is to provide feedback, representing relative proportions of red, green and blue in the colour patch. Along with the light buttons below, they also serve to remind the user of the current layout of the touch tablet.

In this module, the touch tablet is used as a "virtual operating console". Its layout is shown (to scale) in Figure 10. There are 3 valuators (corresponding to the bar graphs on the screen) used to control

[5] Also, there is the problem of friction, to be discussed below under "Inherent Problems".

colour, and two buttons: one, on the right, to bring up a pop-up menu used to select the colour to be modified, and another, on the left, to exit.

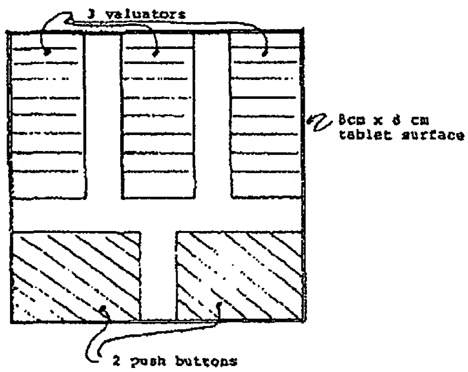

Figure 10. Layout of virtual devices on touch tablet.

The single most important point to be made in this example is that a single *physical* device is being used to implement 5 *virtual* devices (3 valuators and 2 buttons). This is analogous to the use of a display window system, in its goals, and its implementation.

The second main point is that there is nothing on the tablet to delimit the regions. This differs from the use of physical templates as previously discussed, and shows how, in the absence of the need for a physical template, we can instantly change the "windows" on the tablet, without sacrificing the ability to touch type.

We have found that when the tablet surface is small, and the partioning of the surfaces is not too complex, the users very quickly (typically in one or two minutes) learn the positions of the virtual devices relative to the edges of the tablet. More importantly, they can use the virtual devices, practically error free, without diverting attention from the display. (We have repeatedly observed this behaviour in the use of an application that uses a 10 cm square tablet that is divided into 3 sliders with a single button across the top).

Because no template is needed, there is no need for the user to pause to change a template when entering the colour mixing module. Also, at no point is the user's attention diverted from the display. These advantages cannot be achieved with any other device we know of, without consuming display real estate.

The colour of the colour patch is manipulated by *dragging* the red, green and blue values up and down with the valuators on the touch tablet. The valuators are implemented in relative mode (i.e., they are sensitive to changes in position, not absolute position), and are manipulated like one dimensional mice. For example, to make the patch more red, the user presses near the left side of the tablet, about half way to the top, and slides the finger up (see Figure 11). For larger changes, the device can be repeatedly stroked (much like stroking a mouse). Feedback is provided by changing the level in the bar graph on the screen and the colour of the patch.

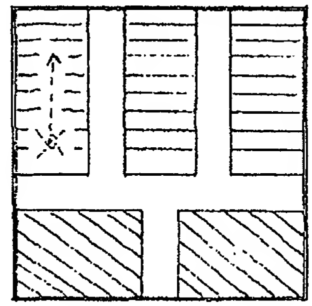

Figure 11. Increasing red content, by pressing on red valuator and sliding up.

Using a mouse, the above interaction could be approximated by placing the tracking symbol over the bars of colour, and dragging them up or down. However, if the bars are narrow, this takes acuity and concentration that distracts attention from the primary task — monitoring the colour of the patch. Furthermore, note that the touch tablet implementation does not need the bars to be displayed at all, they are only a convenience to the user. There are interfaces where, in the interests of maximizing available display area, there will be no items on the display analogous to these bars. That is, there would be nothing on the display to support an interaction technique that allows values to be manipulated by a mouse.

Finally, we can take the example one step further by introducing the use of a touch tablet that can sense multiple points of contact (e.g., [Lee, et al. 1985]). With this technology, all three colour values could be changed at the same time (for example, fading to black by drawing all three sliders down together with three fingers of one hand). This simultaneous adjustment of colours could *not* be supported by a mouse, nor any single commercially available input device we know of. Controlling several valuators with one hand is common in many operating consoles, for example: studio light control, audio mixers, and throttles for multi-engine vehicles (e.g., aircraft and boats). Hence, this example demonstrates a cost effective method for providing functionality that is currently unavailable (or available only at great cost, in the form of a custom fabricated console), but has wide applicability.

5.5. Summary of Examples

Through these simple examples, we have demonstrated several things:

- The ability to sense at least two levels of pressure is a virtual necessity for touch tablets, as without it, auxiliary devices must be used for signaling, and "direct manipulation" interfaces cannot be effectively supported.
- The extension to continuous pressure sensing opens up new possibilities in human-computer interaction.

- Touch tablets are superior to mice and tablets when many simple devices are to be simulated. This is because: (a) there is no need for a mechanical intermediary between the fingers and the tablet surface, (b) they allow the use of templates (including the edges of the tablet, which is a trivial but useful template), and (c) there is no need for positional feedback that would consume valuable display space.
- The ability to sense multiple points of contact radically changes the way in which users may interact with the system. The concept of multiple points of contact does not exist for, nor is it applicable to, current commercially available mice and tablets.

6. Inherent Problems with Touch Tablets

A problem with touch tablets that is annoying in the long term is friction between the user's finger and the tablet surface. This can be a particularly severe problem if a pressure sensitive tablet is used, and the user must make long motions at high pressure. This problem can be alleviated by careful selection of materials and care in the fabrication and calibration of the tablet.[6] Also, the user interface can be designed to avoid extended periods of high pressure.

Perhaps the most difficult problem is providing good feedback to the user when using touch tablets. For example, if a set of push-on/push-off buttons are being simulated, the traditional forms of feedback (illuminated buttons or different button heights) cannot be used. Also, buttons and other controls implemented on touch tablets lack the kinesthetic feel associated with real switches and knobs. As a result, users must be more attentive to visual and audio feedback, and interface designers must be freer in providing this feedback. (As an example of how this might be encouraged, the input "window manager" could automatically provide audible clicks as feedback for button presses).

7. Potential Enhancements to Touch Tablets (and other devices)

The first problem that one notices when using touch tablets is "jitter" when the finger is removed from the tablet. That is, the last few locations reported by the tablet, before it senses loss of contact, tend to be very unreliable.

This problem can be eliminated by modifying the firmware of the touch tablet controller so that it keeps a short FIFO queue of the samples that have most recently be sent to the host. When the user releases pressure, the oldest sample is re-transmitted, and the queue is emptied. The length of the queue depends on the properties of the touoh tablet (e.g., sensitivity, sampling rate). We have found that determining a suitable value requires only a few minutes of experimentation.

A related problem with most current tablet controllers (not just touch tablets) is that they do not inform the host computer when the user has ceased pressing on the tablet (or moved the puck out of range). This information is essential to the development of certain types of interfaces. (As already mentioned, this signal is not available from mice). Currently, one is reduced to deducing this event by timing the interval between samples sent by the tablet. Since the tablet controller can easily determine when pressure is removed (and must if it is to apply a de-jittering algorithm as above), it should share this information with the host.

Clearly, pressure sensing is an area open to development. Two pressure sensitive tablets have been developed at the University of Toronto [Sasaki, et al. 1981; Lee, et al. 1985]. One has been used to develop several experimental interfaces and was found to be a very powerful tool. They have recently become available from Elographics and Big Briar (see Appendix A). Pressure sensing is not only for touch tablets. Mice, tablet pucks and styli could all benefit by augmenting switches with strain gauges, or other pressure sensing instruments. GTCO, for example, manufactures a stylus with a pressure sensing tip [GTCO 1982], and this, like our pressure sensing touch tablets, has proven very useful.

8. Conclusions

We have shown that there are environments for which some devices are better adapted than others. In particular, touch tablets have advantages in many hostile environments. For this reason, we suggest that there are environments and applications where touch tablets may be the most appropriate input technology.

This being the case, we have enumerated three major distinctions between touch tablets and one button mice (although similar distinctions exist for multi-button mice and conventional tablets). These assist in identifying environments and applications where touch tablets would be most appropriate. These distinctions concern:

- limitation in the ability to signal events,
- suitability for multiple point sensing, and
- the applicability of tactile templates.

These distinctions have been reinforced, and some suggestions on how touch tablets may be used have been given, by discussing a simple user interface. From this example, and the discussion of the distinctions, we have identified some enhancements that can be made to touch tablets and other input devices. The most important of these are pressure sensing and the ability to sense multiple points of contact.

We hope that this paper motivates interface designers to consider the use of touch tablets and shows some ways to use them effectively. Also, we hope it encourages designers and manufacturers of input devices to develop and market input devices with the enhancements that we have discussed.

[6] As a bad example, one commercial "touch" tablet requires so much pressure for reliable sensing that the finger cannot be smoothly dragged across the surface. Instead, a wooden or plastic stylus must be used, thus loosing many of the advantages of touch sensing.

The challenge for the future is to develop touch tablets that sense continuous pressure at multiple points of contact and incorporate them in practical interfaces. We believe that we have shown that this is worthwhile and have shown some practical ways to use touch tablets. However, interface designers must still do a great deal of work to determine where a mouse is better than a touch tablet and vice versa.

Finally, we have illustrated, by example, an approach to the study of input devices, summarized by the credo: "Know the interactions a device is intended to participate in, and the strengths and weaknesses of the device." This approach stresses that there is no such thing as a "good input device," only good interaction task/device combinations.

9. Acknowledgements

The support of this research by the Natural Sciences and Engineering Research Council of Canada is gratefully acknowledged. We are indebted to Kevin Murtagh and Ed Brown for their work on virtual input devices and windowing on input. Also, we are indebted to Elographics Corporation for having supplied us with the hardware on which some of the underlying studies are based.

We would like to thank the referees who provided many useful comments that have helped us with the presentation.

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Appendix A: Touch Tablet Sources

Big Briar: 3 by 3 inch continuous pressure sensing touch tablet

Big Briar, Inc.
Leicester, NC
28748

Chalk Board Inc.: "Power Pad", large touch table for micro-computers

Chalk Board Inc.
3772 Pleasantdale Rd.,
Atlanta, GA 30340

Elographics: various sizes of touch tablets, including pressure sensing

Elographics, Inc.
105 Randolph Toad
Oak Ridge, Tennessee
37830
(615)-482-4100

Key Tronic: Keyboard with touch pad.

Keytronic
P.O. Box 14687
Spokane, WA 99214
(509)-928-8000

KoalaPad Technologies: Approx. 5 by 7 inch touch tablet for micro-computers

Koala Technologies
3100 Patrick Henry Drive
Santa Clara, California
95050

Spiral Systems: Trazor Touch Panel, 3 by 3 inch touch tablet

Spiral System Instruments, Inc.
4853 Cordell Avenue, Suite A-10
Bethesda, Maryland
20814

TASA: 4 by 4 inch touch tablet (relative sensing only)

Touch Activated Switch Arrays Inc.
1270 Lawrence Stn. Road, Suite G
Sunnyvale, California
94089

Artificial Reality with Force-feedback: Development of Desktop Virtual Space with Compact Master Manipulator

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ABSTRACT

A new configuration of Human Interface for "artificial reality" is discussed. This paper describes a method of implementing force-feedback in a virtual space manipulation system. The system is composed of two subsystems, a real-time graphic display system and a tactile input device with reaction force generator. A specialized graphics computer (Stardent TITAN) provides a real-time image of the virtual space. A 9 degree-of-freedom manipulator has been developed as a tactile input device. The manipulator applies reaction forces to the fingers and palm of the operator. The generated forces are calculated from a solid model of the virtual space. The performance of the system is exemplified in manipulation of virtual solid objects such as a mockup for industrial design and a 3D animated character.

CR Categories and Subject Descriptors: I.3.6 [Computer Graphics]:Methodology and Techniques - interaction techniques; B.4.2 [Input/Output devices]; H.1.2 [Models and Principles]:User/Machine Systems; J.6 [Computer-Aided Engineering]:Computer-aided design;

General Terms: Algorithms, Performance, Human Factors

Additional Key Words and Phrases: Artificial reality, Virtual reality, Input device, Force sense, Master manipulator, Real-time graphics

1. INTRODUCTION

The recent evolution of intelligent systems requires natural interaction between machines and human beings. A configuration of human interface called "artificial reality" is discussed in this paper. The research objective of artificial reality is to present a computer-generated virtual space to human operator's sense organs: eyes, ears, skin, and so on. Since the major channel of human recognition of the outer environment is the visual sense, real-time computer graphics is essential to artificial reality. Development of computer graphics has been focused on the generation of photo-realistic images, which requires large computational times. Recently, there has been widespread interest in real-time images corresponding with human action.

An early use of artificial reality for human interface was proposed at NASA Ames Research Center in 1986[1]. Fisher, McGreevy, Humphries, and Robinett developed head-mouted display (HMD) and used a glove-like tactile input device (DataGlove). The DataGlove has been utilized in research on telerobotics and user interface design. For example, Zimmerman and Lanier proposed operation of graph language[2] and Hirose et al. proposed operation of a slave manipulator[3]. Through these experiments in manipulation of virtual objects, the need for force output is recognized. Some works for force display devices are found in [4],[5] and [6].

The primary object of our research is implementation of force-feedback in a manipulation system for virtual objects. Compared to presentation of visual and auditory information, methods for presenting tactile information have not been sufficiently developed. Here are 3 classes of tactile input devices:

(1) glove
(2) 3 dimensional mouse
(3) master manipulator

There have been 3 dimensional mice with a force-feedback handle controlled by nine strings. An example device, called "JoyString", was developed by Agronin in 1987[7][8]. These devices generate 6 degree-of-freedom reaction force, but their working volume is limited and there are singularities in their working spaces.

In the field of robotics research, master manipulators are used in teleoperation. Some examples of master-slave manipulators enabling teleperception of remote objects are found in [9] and [10]. Most master manipulators, however, have large hardware with high cost, which restricts their application areas.

In our research, a compact 9 degree-of-freedom manipulator has been developed as a tactile input device on a desktop. The manipulator generates reaction force

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to the palm and the fingers of the operator. Application areas of the system are focused on computer-aided design and 3D animation.

2. SYSTEM CONFIGURATION

2-1. Basic Structure of the System

The virtual object manipulation system is composed of two subsystems, a real-time graphic display system and a master manipulator for tactile input and reaction force generation. A specialized graphics computer provides a real-time image of virtual space. The overall configuration of the system is shown in Figure 1.

A mirror is set in front of an operator's eyes at angle of 45 degrees, which reflects the image on the CRT screen (See Figure 2). The operator can not see the physical world, only the virtual world which includes their hand. This optical configuration immerses the operator in the computer generated virtual space. Articulated graphics of a hand is displayed corresponding with the position and orientation of operator's hand as obtained from the manipulator.

A personal computer provides I/O control of the analog-to-digital (A/D) and the digital-to-analog (D/A) convertors for the manipulator. The graphics and I/O processors are connected by a serial(RS-232C) communication line.

The graphics computer is a Stardent TITAN; the I/O processor is a NEC PC-9801.

2-2. Image Generator Subsystem

The setup of the virtual space is indicated in Figure 3. Motion of the operator's hand is measured by the internal sensors of the 9 degree-of-freedom manipulator. The data is transmitted from the I/O processor to the TITAN. The position and orientation of the hand are described in a coodinate system fixed to the virtual space. Displayed objects with which the hand interacts

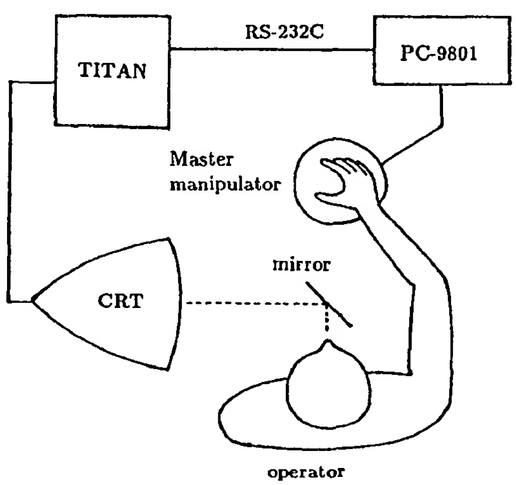

Figure 1. Overall configuration of the system

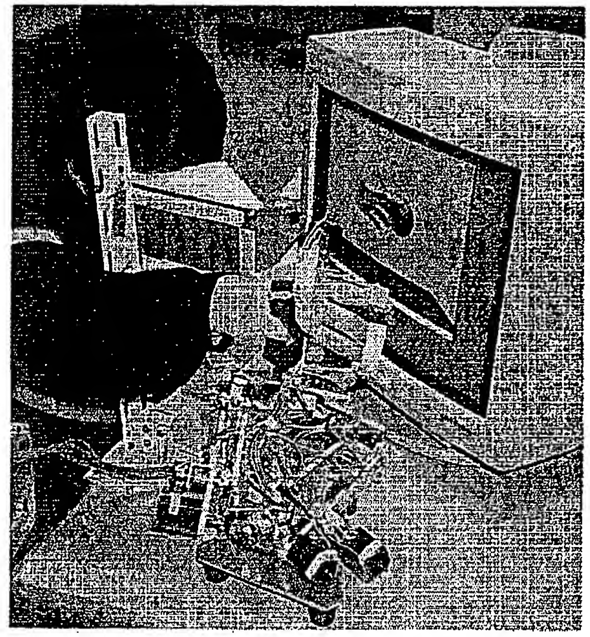

Figure 2. Overall view of the system

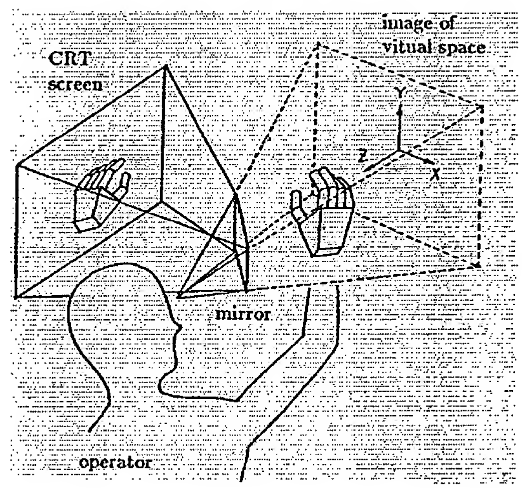

Figure 3. Setup of the virtual space

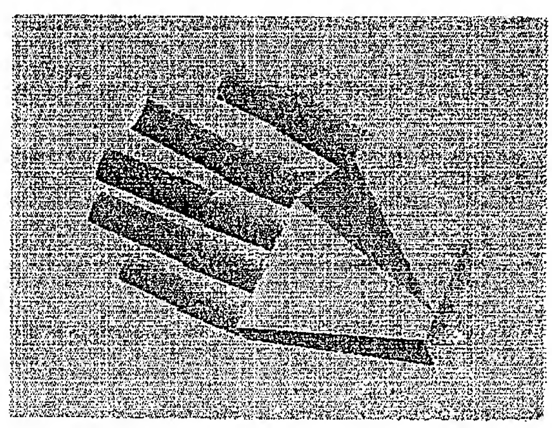

Figure 4. Virtual hand

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are described in the same coordinate system. By adjusting perspective of the "camera", the displayed hand appears the same as the operator's physical hand. An example of the displayed hand is shown in Figure 4. Its image consists of 100 Gouraud shaded polygons.

The TITAN used in the system has 2 CPU boards and its peak performance is 32mips, 32mflops. Development of our graphics application is supported by its Dore library. Our displayed figures are defined as objects, each of which is composed of primitives with attributes. An image is generated by taking pictures of these "objects" with a "camera".

2-3. Tactile Input and Reaction Force Generator Subsystem

A 9 degree-of-freedom manipulator was developed as a tactile input device with reaction force generator (master manipulator). The manipulator applies reaction forces to the fingers and palm of the operator. An overall view of the subsystem is shown in Figure 5.

The core element of the subsystem is 6 degree-of-freedom parallel manipulator. The typical design feature of parallel manipulators is an octahedron, in which a top triangular platform and a base triangular platform are connected by six length-controllable cylinders (see Figure 6). This compact hardware has the ability to carry a large payload. The structure, however, has some practical disadvantages in its small working volume and its lack of backdrivability(reduction of friction) of the mechanism.

In our system, three sets of pantograph link mechanisms based on the work of Tsusaka et al.[11] are employed instead of linear actuators. The mechanism is illustrated in Figure 7. Each pantograph is driven by two DC motors. The top end of the pantograph is connected with a vertex of the top platform by a spherical joint. This mechanical configuration has the same advantages as an octahedron mechanism has. The pantograph mechanism improves the working volume and backdrivability of the parallel manipulator.

The working space of the center of the top platform is a spherical volume whose diameter is approximatly 30 cm. The maximum payload of the parallel manipulator is 2.3 Kg, which is more than a typical hand.

Each joint angle of the manipulator is measured by potentiomaters. Linearity of the potentiomaters is 1%. The non-linearity is not corrected in the current system.

The top platform of the parallel manipulator is fixed to the palm of the operator by a U-shaped attach-

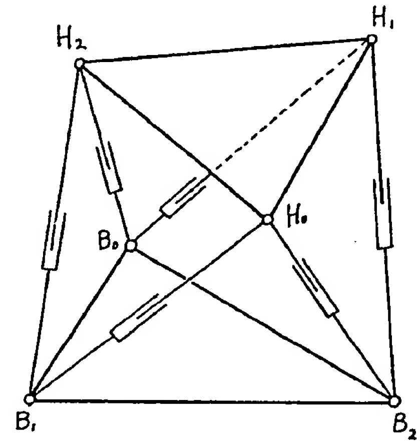

Figure 6. Octahedron mechanism of parallel manipulators

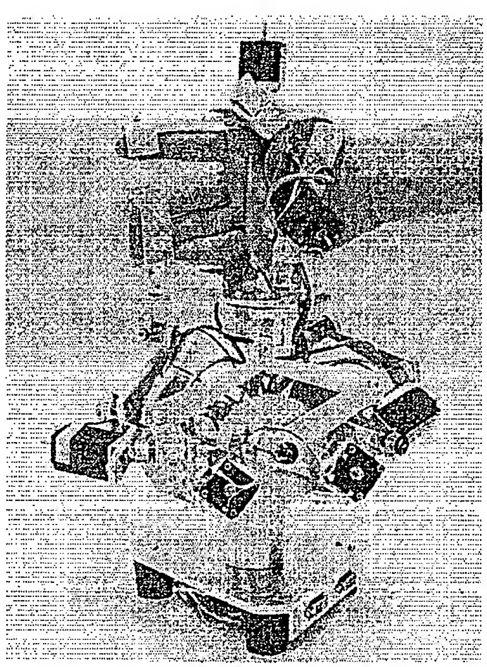

Figure 5. Master manipulator

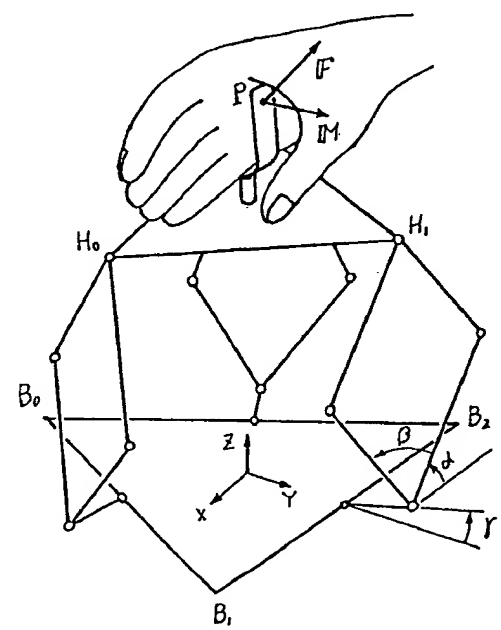

Figure 7. Mechical configuration of the improved parallel manipulator

ment, which enables the operator to move the hand and fingers independently. Three actuators are set coaxially with the first joint of the thumb, forefinger and middle finger of the operator (see Figure 8). The last 3 fingers work together. DC servo motors are employed for each actuator. The maximum torque at each actuator shaft is 3 $Kg\ cm$. Working angle of the thumb is 120 degrees and that of the other fingers are 90 degrees.

We generate force to apply to the hand from the following formulae:

$$L = \sum_{i=0}^{2} F_i \qquad (1)$$

$$M = \sum_{i=0}^{2} [\,(h_i - p) * F_i\,] \qquad (2)$$

$$F_i\,[\,(b_k - b_j) * (h_i - b_j)\,] = 0 \qquad (3)$$

where
P : center of the palm
p : position vector of P
L : force vector at P
M : moment vector at P
F_i : force vector at H_i
h_i : position vector at H_i
b_i : position vector at B_i

The formula (1) indicates the balance of force. The formula (2) indicates the balance of moment. The formula (3) indicates that F_i is involved in the same plan as the pantograph link. The formulae (1),(2), and (3) lead to nine dimensional simultaneous equations. The F_i are obtained by solving the equations by the Gaussian method. Generated motor torques are calculated from the F_i in the I/O processor.

3. METHOD OF MANIPULATION OF VIRTUAL SOLID OBJECTS

3-1 Software Configuration

The core module of the software is a solid model handler implemented on the graphics computer. A diagram of the data flow is illustrated in Figure 9. The I/O processor acquires the joint angles of the manipulator through the A/D converter, and calculates the position and orientation of the hand. A homogeneous transformation is used in the calculation. The position and orientation of the hand coordinate are first described with reference to the base platform. In the next step, the hand coordinates are described with respect to the virtual space. The data of the hand coordinates and bending angle of the fingers are transmitted to the graphics computer.

A solid model of virtual space is updated in accord with the received data. If a finger or the palm touches a virtual object, reaction force is generated. The force and moment vectors for the fingers or the palm are transmitted to the I/O processor. After the transmission, the solid model of virtual space is updated. The torque required at each joint of the manipulator is calculated in the I/O processor from the received force and moment data.

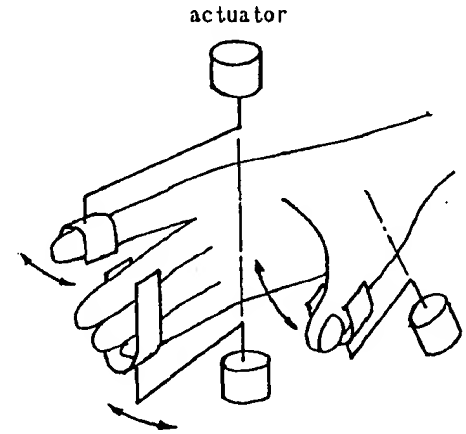

Figure 8. Actuators for the fingers

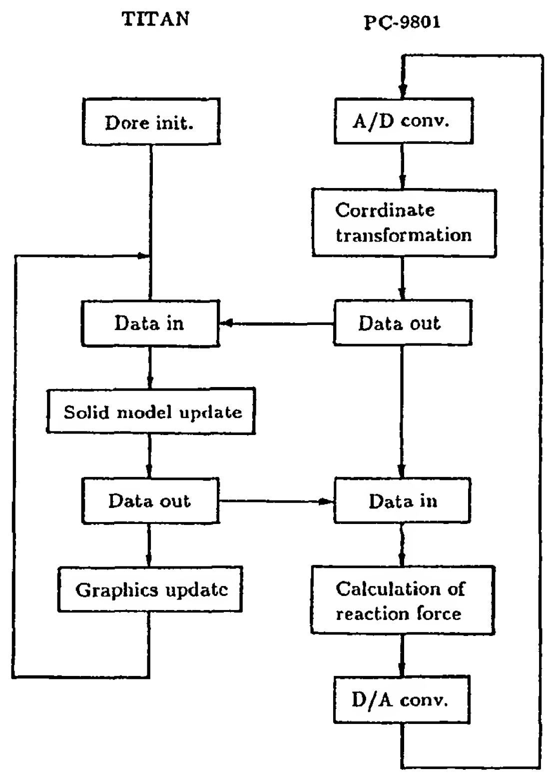

Figure 9. Diagram of the data flow

The computational time for coordinate transformation and actuator torque calculation is 100 $msec$. The computational time for the solid model handling and graphics generation depends on the complexity of the virtual objects. If the virtual object is a simple sphere consisting of 50 Gouraud shaded polygons, these processes require approximately 0.5 seconds. This time currently includes the large overhead of updating X window software. Since the Dore library is designed to be used in X window environment, this overhead is unavoidable at present. The computational time in the graphics com-

puter determines the performance of the force feedback device. In our current example, the sampling rate is 4 Hz and lag time is 0.25 seconds. We are planning to separate graphics and force update, which improves the sampling rate to 10 Hz.

3-2 Solid Model Interaction

The contact of the virtual hand with virtual objects is detected at the 16 control points shown in Figure 10. The distance between these points and the surface of a virtual object is calculated. If the thumb and one of other fingers touches a virtual object, the object is regarded as captured. After the capture, virtual object coordinates are fixed to the hand coordinates so that the object moves with hand as though gripped.

Reaction forces to the fingers are generated according to the solidity of the captured object. If the object is a rigid body, the maximum possible torque is transmitted to the fingers to present the hard surface of the object. The force and moment vector at the palm is determined with respect to the position of palm and the object, according to the mass distribution of the object. In the case of handling a camera, for example, these vectors are obtained as follows (see Figure 11):

$$F = G \qquad (4)$$

$$M = G * (c - p) \qquad (5)$$

where
P : center of the palm
p : position vector of P
F : force vector at P
M : moment vector at P
C : Center of gravity of the camera
c : position vector of C
G : gravitational force vector at C

The formula (4) indicates the balance of force. The formula (5) indicates the balance of moment.

4. APPLICATION AREAS

Artificial reality is expected to be applied to various categories of human interface. Our application of the virtual space manipulation system is focused on two major fields of application of computer graphics: computer-aided design and 3D animation.

(1) Virtual handling of prototype products

The tactile sense plays important roles in the perception of size or shape of an object. These attributes cannot be directly perceived through planar CRT screens and conventional pointing devices. Touch-based artificial reality applied to a CAD system enables a designer to virtually handle prototype products during the designing process. An example of handing a virtual camera is shown in Figure 12. The operator can feel the mass balance of the product. The refresh speed of this application

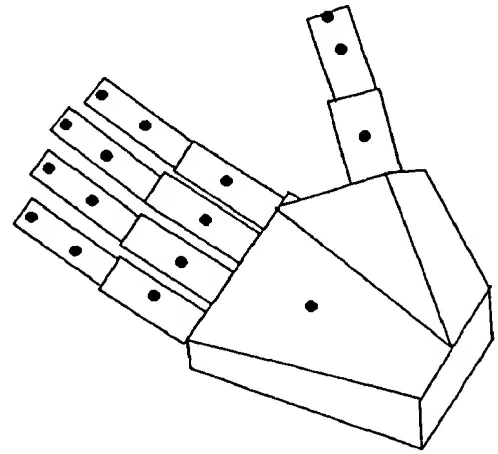

Figure 10. Control points on the virtual hand

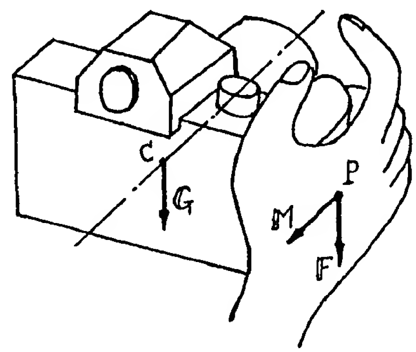

Figure 11. Force and moment vectors at palm

is 3.8 frames per second. The virtual camera consists of 80 Gouraud shaded polygons, and the simulated mass is 0.5 Kg .

(2) Choreography for 3D animated character

Application of computer graphics to amusement is making progress. 3D animated characters are popular in TV programs. Choreography for these characters is not easily done with conventional pointing devices. An example of handling a 3D animated character with our virtual space manipulation system is shown in Figure 13. The refresh speed of this application is 3 frames per second. Artificial reality may enable a choreographer to join in the production of 3D animation.

5. CONCLUSIONS

This paper has shown a method of implementation of force-feedback in a virtual space manipulation system. The design of a compact nine degree-of-freedom master manipulator and its interaction with solid models was discussed.

Future directions in this research:
(1)Presentation of sense of touch

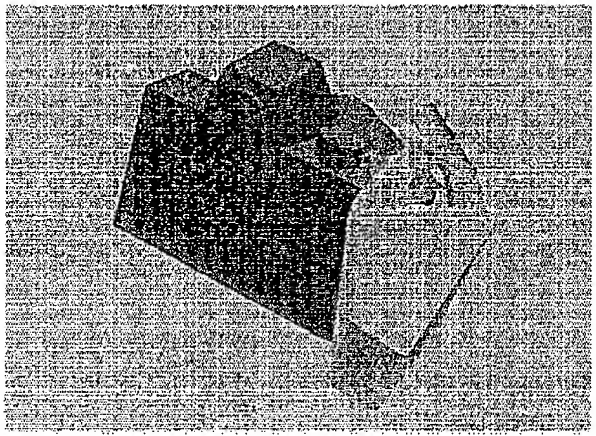

Figure 12. Handling of a virtual camera

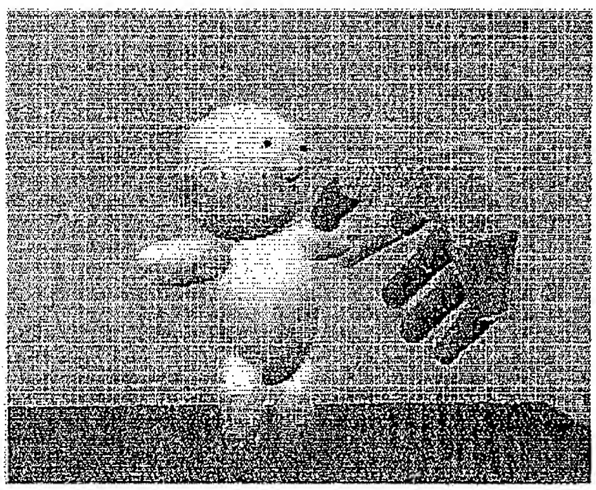

Figure 13. Handling of a 3D animated character

The link mechanism as shown in this paper has limitations in presenting delicate tactile sensations such as the feel of the surface of an object. A new micro mechanism for presentation of these sense is desired.

(2)Application for interactive visualization

Artificial reality has an ability not only to simulate the real world but also to create an alternative reality. Objects without substance, such as computer software, could be visualized and operated in this alternative reality. For example, if a data structure of a large scale database system could be presented in rigid or flexible objects with mass, a programmer would easily perceive its global image.

Acknowledgments

The components of the parallel manipulator were machined by the Machining Center of the University of Tsukuba. This paper would not have been possible without their efforts.

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Feeling and Seeing: Issues in Force Display

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Introduction

This paper is about using the sense of touch, the haptic system, as part of our everyday interface with computationally created worlds.

In Part I, we discuss a particular system, called *Sandpaper*, designed for experimenting with feeling texture. In part II, we discuss how control analysis helps us understand the behavior of the types of hardware and software we use to implement force display.

We will not comprehensively review the literature of force display devices and their applications; descriptions can be found in e.g. [Sutherland65], [Noll72], [Batter72], [Atkinson77], [Brooks88], [Ouh-young88], [Smith88].

Part I

Force display technology works by using mechanical actuators to apply forces to the user. By simulating the physics of the user's virtual world, we compute these forces in real-time, then send them to the actuators so that the user feels them. The force display technology we use in the *Sandpaper* system is a motor-driven two-degree of freedom joystick (built by Max Behensky and Doug Milliken). The joystick position is reported to the software, which computes the appropriate forces for the joystick's motors.

Why create texture?

Force display is especially useful for communicating surface texture and bulk properties of objects and environments as well as dynamics of objects. In this way force display technologies augment the strengths of computer-generated graphics and sound in creating convincingly realistic environments (figures 1, 4).

In the *Sandpaper* system, we use a novel technique to allow the user to feel textures. We create very small virtual springs which pull the user's hand toward low regions and away from high regions of a texture's depth map. We synthesize finely spaced grooved surfaces and also use depth data from Perlin's noise textures [Perlin85] and fractals supplied by Pentland [Pentland84]. We also create feel-able physics such as variable viscosity soups, springs, and yo-yos (Color plate 1).

We believe it is particularly important to allow the user to make exploratory motions as if they were touching real objects and materials [see Lederman87]. This informs our empirical studies and our design of future force display devices.

Surfaces as perceived by the human haptic system derive from a complex combination of shape and material properties. Texture is one of the most important such properties. What is salient about a surface may also involve other percepts, such as softness, apparent temperature, and so forth [Katz25]. We believe that we can make computer interface systems which can synthesize all of these; in order to do that we need to understand both the perceptual and computational issues.

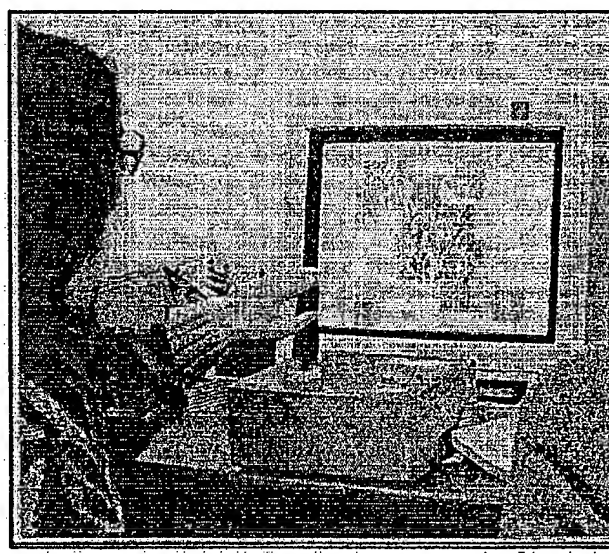


Figure 1 Photo of "Sandpaper" System In Use

Empirical Studies of Roughness Perception

Our application is a computer-supported software and hardware system to do research on texture perception.

[1]Present address: Apple Computer, Inc., Cupertino, CA
[2]Address: Atari Games, Milpitas, CA

The system was designed as a laboratory for conducting experiments on touch and haptic perception. An experiment we envisioned is the following: the user is presented with several pieces of sandpaper and is asked to arrange them in order of roughness, exploring them by finger touch, and sliding them on a table in front of him. This experiment takes place in a virtual environment using a force feedback interface; the textures are created computationally with characteristics controlled by software. (Our experiments are adapted and simplified from psychophysical studies by Lederman and others; see, for example, [Lederman72].)

We created patches of texture intended for testing roughness perception. There were two major goals: first, to provide a flexible testbed for testing human perception of roughness and for creating the stimuli for such experiments; and second, to understand differences between the perception of computationally created textures and the perception of real textures in the interest of creating textures which sustain the illusion of objects in virtual realities.

Evidence that texture simulation works

In a pilot study, subjects believed that they were feeling patches of textured material.

In an anecdotal experiment, subjects were presented with a variety of textured patches (visually masked) in the *Sandpaper* environment. They were asked to arrange the patches in order of roughness. Subjects ordered the patches with a moderate degree of consistency. We interpret this to mean that subjects are able to judge roughness of these patches, and can discriminate degrees of roughness. Since we use a variety of surface models, we do not know which aspects of the simulated surfaces contribute to the perceived roughness.

In another pilot study subjects were asked to adjust parameters of a patch. They were asked to find the minimum and maximum values of a parameter within which a patch feels like it has a "surface texture". In particular, we allowed subjects to adjust a force amplitude parameter (which may correspond to bump depth), for patches with Perlin noise and fractal depth maps. We allowed subjects to adjust a parameter corresponding to the spacing of grooves in a very simple model of grooved surfaces. With a small number of subjects, we saw suggestive consistency in these results.

Pilot studies of roughness perception suggest that we can successfully create varying degrees of perceived roughness. However, the spatial parameters that determine perceived roughness of virtual grooved surfaces may not be the same as those which are correlated with perceived roughness for real grooved surfaces as observed by Lederman and Taylor [Lederman72]. Preliminary data suggests that roughness of simulated surfaces may be closely correlated with spatial frequency, although there are several other likely hypotheses.

How to Create Simulated Textures

First, we oversimplify by saying that texture is made of little bumps. The little bumps are surface features in the range from a few microns up to millimeters.

Previously, we had created the illusion of bumps and valleys by the following trick: As the user moves the joystick in a direction which is "up" a bump, his motion is opposed by a spring force proportional to the height of the bump. This gives the sense that it is very difficult to move to the top of the bump (springs resist being stretched), and easy to fall off the bump back into a lower region of the simulated surface (springs like to revert to a short length).

We had made fairly large scale bumps whose apparent heights were determined by the stiffness of the surrounding springs. This technique has been used by several groups working with force display technology to create artificial detents (spring force toward the bottom of the detent).

We extended this technique to fine grained surfaces by computing spring forces based on a local gradient: As the user moves the joystick on the virtual surface, the change in height in the direction of motion is noted. We create virtual springs opposing the motion "up" the sides of each tiny bump. Thus the spring forces applied to the hand are computed from local gradients of the height of the surface (figures 2,3).

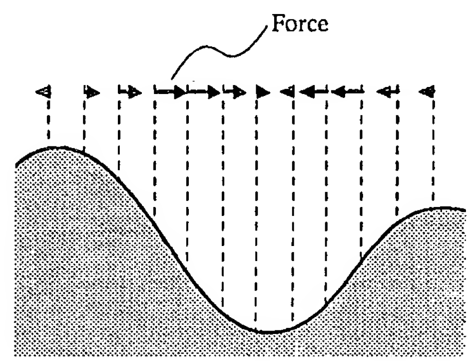


Figure 2 Gradient Technique: enlarged cross section of surface depth map

The texture forces are computed in real-time from a texture depth map. In some cases the depth map is stored and in some cases it is computed on the fly from a procedural representation of the texture.

Our system associates a screen picture with each patch. Usually we associate a shaded rendering of the appropriate texture with what the user feels as he manipulates the patch. Sometimes, for purposes of our experiments, we "paint over" the patch to give little visual feedback; sometimes we even display conflicting visual information.

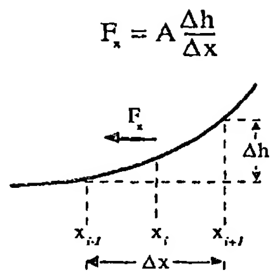


Figure 3 Gradient technique: detail of local spring force computation for x direction; y direction is similar

Force Display Requires Real-Time Physics and Animation

The approach outlined above for simulating texture is a combination of lookup of material properties and real-time computation of system dynamics. In the texture computations described above, we compute forces locally.

Textbook objects

This approach implies a physical interpretation of the algorithm for generating forces. Any physical system can be created from a combination of ideal "textbook" objects: springs, dampers, and masses:

Spring	**Force = k*position.**
Damper	**Force = b*velocity**
Mass	**Force = m*acceleration**

For textures, we currently compute forces based on local position information, which we then interpret as virtual springs. Sometimes we compute other dynamics as well in order to simulate material properties other than local slope. For example, we sometimes apply viscous damping forces to stabilize our simulation (see Part II).

In fact, in our system we model a variety of non-textural physical systems as well. We needed to perfect our models of pure springs, dampers, and masses in order to create textures, and we also have patches of materials such as molasses and ice, and patches containing bricks to push, lassos to twirl, and independently moving objects which try to drag the user's hand about.

In general, to model *any* dynamic system, we model a combination of the user and the force display device itself. We must sense the position, velocity, and acceleration of the joystick, and then use geometry and equations of motion to compute the appropriate output forces.

We can compute modest physical setups and animated displays in real time. Sometimes it is easier or necessary to precompute forces, or some other aspect of the environment that will be queried to produce the forces. For example, a square-wave grooved surface should be easy to produce purely procedurally, but its very steep walls cause local instabilities in the physics simulation (see Part II). We have to filter the depth map of the grooved surface in advance. In general, this kind of filtering is too slow to do in real time.

Physical modeling in a sampled, digital world requires attention to signal processing techniques. We learned several techniques which allowed us to increase fidelity to real-world physics and stability. The spatial filtering mentioned above is an example. We also temporally smooth our acceleration and velocity data. This can smooth the feel of the simulation, at the expense of increased apparent viscosity, mass, and lag. Thus some techniques required us to make tradeoffs to achieve reasonable results.

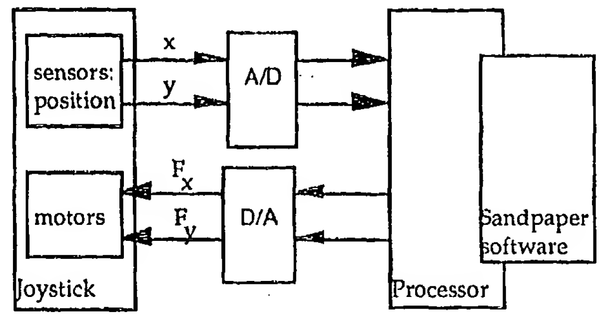


Figure 4 Block Diagram of Hardware System

Patches of Feel-able Material are Objects

Since our primary aim was to create moveable patches of textured surfaces, we decided to represent each patch visually as a rectangle on the screen that could be manipulated by the user.

Internally, a patch is an object with state. Each patch is associated with either a procedure that runs each clock tick to produce forces, or with an array of precomputed force values to be looked up on the basis of joystick position. The patch is associated with its visual representation, a pattern or a bitmap.

Each patch has several parameters. For example, a patch representing a finely grooved surface has parameters for the height and spacing of the grooves. A patch may also have other parameters: for example, the viscosity of the virtual medium in which the user's hand is moving, or the apparent mass of the joystick. The *Sandpaper* system allows any of these parameters to be controlled by screen-based sliders which the user can adjust.

This approach to the design of the system was vital for the kind of empirical work now required. For example, in creating a simulation of a mass (think of wielding a brick on the end of the joystick) there were several parameters whose values were critical (mass, viscosity, spring constant, and temporal filter coefficients). By tuning these parameters in an interactive loop, and *feeling* the response of the system, we were able to create stable masses. However, our

experiences with empirically varying ill understood parameters prepared us to appreciate the analyses offered in Part II!

The ability to create patches in the same family, but with different parameter settings, and to vary the parameters of a patch in real time are important not only to the implementor of virtual materials, but also to the experimental psychologist who is a user of our system. For example, an experiment can be designed in which the subject is asked to vary a texture until it matches a reference.

How Much Must the Environment Suggest Physical Reality?

Interface metaphor and graphics must enhance the touch illusion of virtual patches of textured material that can be directly manipulated by the user. We used direct manipulation conventions from the Macintosh interface as much as possible. A challenge was to keep the visual contents of the patches constant as they are dragged; this quality of animation is vital for a sense of physical reality.

We tried various experiments to increase the sense of physical reality. What should happen when the user wants to move a piece of sandpaper? Should he be able to pick it up? We simulated this by having it become the topmost layer. Should it slide? We simulated this by maintaining a two-and-a-half-d ordering of the patches according to the order in which they were originally placed on the table. Each of these strategies gives the user a different impression of the physical environment in which he is manipulating the material. These are visual strategies. The next step is to model the physical interaction forces between the patches so that heavier materials are harder to drag than light ones, and rough materials are harder to drag past each other than smooth ones.

The haptic sense as it is used to explore an environment, is a combination of cutaneous and kinesthetic senses with intentional exploratory motions. We believe that users' freedom to perform the appropriate exploratory motions strongly affects their perception of a simulated physical environment.

Lederman and Klatzky [Lederman87] assert that stereotypical hand motions are associated with exploring objects for certain features. In particular, "lateral motion" is associated with texture. In pilot studies within the *Sandpaper* environment, we observed that subjects used this stereotypical motion when asked questions about texture properties of patches. Subjects complained in a variety of ways when patches were too small to allow this motion while staying within the patch; making the patches bigger removed these vague discomforts.

The joystick interface raises the question of whether perception in the *Sandpaper* environment is more like perception of objects directly with the hand or perception through a handheld tool. Although the joystick ostensibly resembles a handheld tool, we have had some success in bringing the perceived location of our textured surfaces very close to the hand, by building an apparatus that changes the physical appearance of the joystick and the way the hand can grip it.We cover the joystick with a black box, and mount a ping-pong ball on its end. The ball appears to be sliding a flat black surface. About one half of our subjects perceive the textured patches with this arrangement to be directly beneath the hand.

Conclusion: Moving to higher level descriptions

We have emphasized description of texture in terms of mechanical impedances and low level physical models. In fact, geometric and physical models are our way now to implement feel-able physical and shape properties of objects.

It is important to move to descriptions at higher levels including those informed by perceptual dimensions, detailed knowledge of which we hope to gain through further perception experiments. For example, we would like to describe a surface in terms of degrees of roughness, softness, and stickiness rather than in terms of density and placement of tiny bumps.

Our planned perception experiments should uncover mappings between these percepts and the physical parameters of our simulations.

We can then make higher level descriptive building blocks to create full three dimensional virtual worlds containing passive and active objects and ambient media.

Future

Further quantitative studies on texture perception must be performed using simulated surfaces. In particular, we are developing better models of grooved surfaces to be used in studying roughness perception.

We will report on studies of the roles of texture and *other* properties of simulated objects perceived by the haptic system in virtual worlds. We emphasize observations of the motions made by users, in order to understand how exploratory activities used in the real world may be used in virtual worlds. It is as important to integrate our system with sound cues as with visual cues; that is part of our work in progress.

We are beginning work with a three degree of freedom joystick (x,y,and z) [Smith88, Russo90], and will compare our two-degree-of-freedom results with those obtained in true 3D. We expect to map our textures onto the surfaces of three dimensional objects, and also to create soft surfaces and "volume texture".

We will report progress and recommendations in using force display in particular virtual worlds; for example, teleoperation, surgical simulation, and sculpture.

Part II: Control Issues in Force Display

To analyze the methods for creating an illusion of feel in Part I, we investigated a variety of control issues in force display:

1. Analyses to address the question: What is the required system updating rate for system A doing simulation B? Analyses using control theory yield the stability conditions among sampling period, mass, stiffness, and viscosity in various simulations.
2. Measurements on a force-feedback joystick and an ARM (Argonne remote manipulator). The experimental data support our predictions from theory. We used the Sandpaper system to conduct several interesting experiments, and used the analyses in control theory to explain these strange phenomena (some of which are counter-intuitive).
3. Measurements on the human arm. We followed Hogan's approach and found that there is a significant difference in human arm impedance between radial motion (forward-backward) and tangential motion (side-to-side) when holding a joystick [Hogan89].

What destroys an illusion of feel?

In general, data conversion and computer speed limits the attainable sampling rate in force display. For real-time computer graphics, 15-30 frames/second performance proves enough for acceptable visual illusions. What is the minimum sampling rate for good perception of force through a human arm? This question relates to human response time, human arm dynamics, system performance, and what is being simulated.

One thing is certain, if the system is inherently unstable, the illusion of a real object is destroyed immediately. Another criterion common both to computer-generated images and computer-synthesized force fields is that the displayed object cannot jitter if it is supposed to be stationary in time. Noise (quantization noise, thermal noise in potentiometers, noise in transmission lines, and noise in electronic components) in input data causes jitter problems. Bad force-field simulation/system dynamics causes inherent instability, which is intimately related to the sampling period.

Impedance control theory

How to create an illusion that one is holding a real object? Let's be more specific. Given a computer controlled joystick, can we simulate the dynamics of a spring-mass system including its mechanical impedance (mass, stiffness, viscosity)? If we can simulate the mechanical impedance then one cannot tell whether an object is real (using tests of Newton's three laws of motion). In theory, we can do this simulation, if we can measure the position, velocity, and acceleration of the hand-controller precisely, and can calculate and deliver the outputs continuously and without lag.

The following analysis follows the impedance control theory introduced in [Hogan87]. Suppose the joystick has mass m, stiffness k, and viscosity b. Define position as x, velocity as v, acceleration as a, the force generated by the motor controlled by a computer as F_s, and force measured by a force sensor as F_{ext} (Fig. 5).

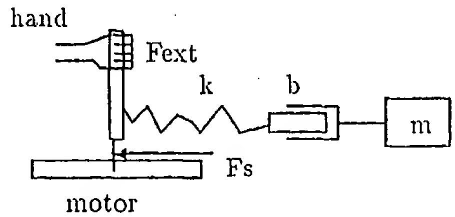


Figure 5: A joystick system

$$ma + bv + kx = F_s - F_{ext} \tag{1}$$

Suppose the target virtual spring-mass system has mass M, stiffness K, and viscosity B, then the force measured at the sensor is

$$-F_{ext} = Ma + Bv + K(x - x_0) \tag{2}$$

where x_0 is the rest position. From 1, the force required at motor is

$$F_s = ma + kx + bv + F_{ext} \tag{3}$$

from 2, let $1/M = W$

$$a = W[K(x_0 - x) - Bv - F_{ext}] \tag{4}$$

substituting 4 into 3

$$F_s = mW[K(x_0 - x) - Bv] + kx + bv + F_{ext}(1 - mW) \tag{5}$$

Equation 5 says that if the position x, velocity v, and the force from sensor F_{ext} can be measured, the system can simulate any object by controlling motor forces only.

A method for creating an illusion of feel

The goal is to simulate a spring with stiffness K, mass M = m, and no viscosity. Instead of doing the detailed simulation in the ideal case, we choose to use a very simple method: let the joystick synthesize the spring force based on position feedback only. The question becomes, what does the human arm really feel?

Let $F_s = K(x_0 - x)$ in our simulation. From Eq. 5, assuming joystick stiffness (without power) is zero.

$$\begin{aligned} -F_{ext} &= -[K(x_0 - x) - ma - bv] \\ &= ma + bv + K(x - x0) \end{aligned} \quad (6)$$

The true behavior of the system, and so the feel to the human arm as an external observer, is like holding a spring with stiffness K, mass m, and viscosity b. Although this is not exactly the target spring system (mass m, stiffness K, viscosity 0) in simulation, it is close to the target system if viscosity b is small.

With this simple approach, we successfully built dynamic models in Sandpaper system, and a molecular docking system. In the docking system, let $F_s = \sum f(x_i)$, x_i is the position of atom i, and $f()$ is a molecular force field function (color plate 2) [Ouh-young 88].

Contact instability and the human arm

Ideally a computer controlled joystick/hand-controller can simulate any target dynamics. However, in practice almost all systems have *contact instability* problems near a wall (a hard surface). There are several reasons,

1. If a digital computer is used in simulation, sampling delay can make a stable system unstable.
2. If one doesn't have measured external force F_{ext}, and approximates it with a velocity derivative, noise and delay are introduced.
3. The two different locations for sensor and actuator cause an instability problem (the non-colocation problem). The dynamics of the link (for example, the lower-arm of the ARM) itself are usually not properly modeled: the link is not a point mass, but is actually a distributed mass [Colgate 89].

Of course, one can make the system stable by adding extra viscosity, or by reducing the stiffness of the simulated hard surface. The former makes the human feel resistance and sluggishness even in free space, whereas the latter makes the hard surface spongy.

To make the problem even more complicated, the system is far from linear. The human operator's own physical characteristics are involved in the feedback loop in exploring the virtual world, and he changes those parameters dynamically and radically. Lanman reported human elbow stiffness to vary from a minimum of about 1.4 N-m/rad to a maximum as high as 400 N-m/rad [Lanman 80]. Cannon and Zahalak's measurements showed that both the limb's natural frequency and damping ratio vary with muscle activation [Cannon82].

Theoretical analysis [Murray 88] showed that a second-order model with parameters varying with muscle activation and elbow angle was unable to reproduce experimental observations. A simplest competent characterization required a fourth-order model. A fifth-order model was used by Hannaford [Hannaford89].

Hogan has experimental data to show that a human arm can be accurately modeled as a passive object with constant impedance for periods up to 1.2 seconds [Hogan89]. That is, it takes that long to change muscle impedance, rather than the 200 ms neuromuscular response time one might have expected.

All these data make satisfactory hard-surface simulation unlikely. But here is good news. First, multiple-sensory illusions (vision, force, sound) reinforce each other. Second, even though the system may become unstable during the simulation, the human operator can compensate or avoid it.

Analysis

What will be the behavior of the spring-mass system when a human arm is combined with it? Assume the human arm can be modeled by a second-order system with mass Mh, stiffness Kh, and viscosity Bh. If the arm is not generating forces, the system dynamics equation becomes

$$(Mh + m)a + (Bh + b)v + (Kh + k) * (x - x0) = 0 \quad (7)$$

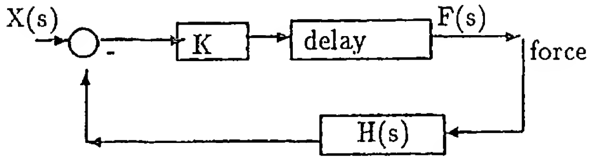
where a = acceleration, v = velocity, x = position, $x0$ = initial position, m = mass of joystick, b = viscosity of joystick, and k = stiffness of a virtual spring. The natural frequency f of the system is given by $2\pi f = \sqrt{(Kh + k)/(Mh + m)}$.

Delayed analog analysis

One way to predict the dynamics of Eq. 7 is to use analog control theory, and add a time-delay component in the feedback loop (Figure 6). We give a simple analysis of a spring and mass system (mass M, spring constant K, and viscosity B), with the human arm not included at first. Even though the delay (e^{-sT}, T is the delay in seconds) is introduced, this is still an analog controller. We use this model to get some insights before going on to the complicated digital controller.

Assuming that the product of the delay T and the natural frequency s is small, say less than 0.1, then e^{-sT} can be approximated by second-order Taylor series expansion.

$$e^{-sT} = 1 - sT + 1/2s^2T^2 \quad (8)$$



where K = spring constant,
$H(s) = 1/(Ms^2 + Bs)$, M: mass, B:viscosity,
delay = e^{sT},T: sampling period

Figure 6: An analog system with delay T

The transfer function between output force and input position becomes

$$\begin{aligned} F(s)/X(s) &= Ke^{-sT}/[1 + KH(s)e^{-sT}] \\ &= (Ms^2 + Bs)Ke^{-sT}/[K + (M + \\ &\quad 1/2KT^2)s^2 + (B - KT)s] \end{aligned}$$

By the Nyquist stability criterion, if one of the poles of F(s)/X(s) is located on the right-half of the s-plane, the system is unstable. The poles of F(s)/X(s) are equal to zeros of X(s), and are given as

$$[(KT - B) \pm \sqrt{(B - KT^2 - 4(M + 1/2KT^2))}]/ (2(M + 1/2KT^2))$$

The system becomes unstable if $KT - B > 0$, where K is stiffness of the system, T is delay, and B is viscosity. This is an approximate solution. There is a constant C involved in this relation, i.e., T > C*B/K, and C is shown to be approximately 2 in more detailed discrete simulations.

When the human arm is combined with the system, let K = Kh + k, M = Mh + m, B = Bh + b, and $T < C*B/K$ still holds (see notations in Eq. 7).

A true discrete analysis

With a discrete model the solution is not in closed form, and we have to use numerical simulation to get insights from it.

Doing so we made the following observations. Let T^* be the maximum sampling period that makes the system stable.

1. T^* is linearly related to 1/K, where K is spring constant.
2. T^* is linearly related to viscosity B over a wide range, and then becomes nonlinear (when $B > 16$ N-sec/m) .
3. T^* is actually not related to spring mass M when the mass is over a threshold (0.02 Kg).

To understand this solution, suppose B (the viscosity) is small, as in many virtual world simulations, and K (the spring constant) is big, then the system delay T can easily be bigger than 2*B/K. A typical example would be B = 1.17 N-sec/m (joystick), a strong spring K = 400 N/m, and T > 2*B/K = 5.9 ms can cause instability. This places a severe restriction on the force fields that can be simulated by a slow update-rate system.

Similarly, if one simulates "stirring a rod in a tank of viscous oil" by $F_s = Bv$, where v is the joystick velocity, B is the desired viscosity, the stability condition is $T^* < C1 * M/B$, and $C1 = 2$.

Hard surface simulation with low sampling frequency

The following is an interesting experiment constructed to test the results from above discrete analysis.

> Procedure: In hard-surface simulation, let the system first run at 1000 Hz, then run at 250 Hz, then run at 100 Hz. Running at 100 Hz, when one bumps into the hard surface, the program increases viscosity to three times of human arm viscosity (5 N-sec/m), i.e., Bs = 15 N-sec/m.
>
> Results: At 1000 Hz, the system is stable; at 250 Hz, the system is unstable; at 100 Hz, the system is stable again. At 100 Hz, the subjects "feels" the same hard surface as if the system was running at 1000 Hz.

Parameters in this experiment.

Ks	Kh	Bs	Bh	Bs (within hard-surface)
2773	400	1.17	5	15

Mh (in Kg), Kh (in N/m), Bh (in N-sec/m) are human arm mass, stiffness, and viscosity; Ms (in Kg), Ks (in N/m), Bs (in N-sec/m) are joystick mass, stiffness, and viscosity.

Explanation: in order to be stable, $T < 2 * (Bs + Bh)/(Ks + Kh)$. The system is unstable in hard surface simulation at 250 Hz, since $(5 + 1.17) * 2/(2773 + 400) =$ 3.84 ms = 260 Hz. If the program increases Bs from 1.2 to 15 N-sec/m, three times of human arm viscosity, even the lower sampling rate (100 Hz) makes the system stable, since $(5 + 15) * 2/(2773 + 400) = 12.6$ ms = 79 Hz.

In our experiments, the subjects did not feel the viscosity difference, however, it helps tremendously in reducing the required sampling frequency

This was a very useful observation, and it shed light on other implementations. Possible conditions when the viscosity can be added without the loss of performance (in terms of human feeling) are:

1. within the hard-surface, which needs geometry information.
2. in any region where the equivalent stiffness is above a threshold (which causes instability at the given sampling rate). This can be implemented as a simple threshold function: if $2B/K > T$, let $B_{new} > TK/2$.

Hard surface simulation with two different hand motions

Procedure: use the joystick to bump into a hard surface, which is simulated by a spring with stiffness 2773 N/m, with sampling period at 2.8 ms.

Results: the tangential motion (side-to-side) is always unstable, but the radial motion (forward-backward) is always stable for all thirteen subjects (graduate students in the graphics laboratory).

Parameters used in this experiment.

Ks	Kh	Bs	Bh (tangential)	Bh(radial)
2773	400	1.1	3	10

Explanation: there is viscosity difference between radial and tangential motion. The stable condition is $T < 2*(Bs+Bh)/(Ks+Kh)$. In the case of tangential motion, the system is unstable since 2*(1.1+3)/(2773+400) = 2.6 ms is smaller than the required sampling period of 2.8 ms. However, in the case of radial motion, it is stable, since 2*(10+1.1)/(2773+400) = 7.0 ms is well above 2.8ms.

Two puzzles about the behavior of human arms

We encountered two puzzles during the study of force display. First, how can the normal human be stable, even though the neural-muscular response time is around 200 ms? The puzzle was raised when the joystick we used had a sampling frequency of more than 30 Hz and still could easily be unstable. Is it because the human arm has a better way to compensate the system dynamics? The other puzzle is that even though the joystick sampling frequency was increased from 500 Hz to 1000 Hz, the human arm could still feel the difference in some cases.

In drama and literature, the human arm has been portrayed as the wings of a swan, the fists of a bear, the hammer that strikes the bell, and a piece of iron in a warrior. These magic tasks of human arms were created by illusions that looked realistic to human eyes.

Why is human arm always stable for a healthy person? If we assume that the human arm is implemented by a digital controller, the sampling period T must be smaller than 2*Mh/Kh in order to be stable. Typical values of Mh = 0.8 Kg and Kh = 500 N/m show that T must be smaller than 3.2 ms! Obviously this is not a correct model, since the known human neural-muscular response time is much bigger than 1.6 ms, and is around 200 ms.

Hogan coined a term *digitally supervised analog control* [Hogan87]. The idea is that an analog controller can eliminate sampling problems, at the same time allowing some control parameters to be updated by a digital computer infrequently and asynchronously.

Similarly, here we can think of a human arm as an analog controller supervised by the mind. But this mechanism is not perfect. Suppose the human arm wants to act like a piece of paper floating in the air, or an iron with big mass, the *digitally supervised analog control* is simply inadequate. The reason is that even though the human arm can sense the external force and change the muscular force, stiffness, and viscosity, the time delay is too big to make the arm act like a paper or an iron. Try the task of letting your hand behave like a piece of paper encountering a striking stick. Although one can see the coming stick by its trajectory, and feel its contact with the skin, it is impossible for one to make one's hand act like a piece of paper.

The second puzzle is that even though the joystick sampling frequency is increased from 500 Hz to 1000 Hz, the human arm can still feel the difference in some cases. Considering that human neural-muscular response time is about 200ms, this phenomenon is hard to explain at first. Our explanation to this puzzle is that although the joystick is running at 500 Hz, it may be unstable at that frequency when it is stable at 1000 Hz. The vibrations caused by this instability can be sensed by human hand, since there are skin sensors tuned as high as 400 Hz (sensitive to a range from 2 Hz to well over 500 Hz) [Sherrick86]. If the system is stable under both sampling rates (500 Hz and 1000 Hz), we observe that there are no gross differences in force perception in a few simulations in the Sandpaper environment. We hypothesize that the stability of a simulation is a major criterion in differentiating between them.

Conclusion

We did not use all the theories in designing our first systems. When problems came one by one, we realized that an analysis would be useful. The analysis helped us understand and improve the performance of our current systems, and we believe it will also contribute to the design of new force display systems.

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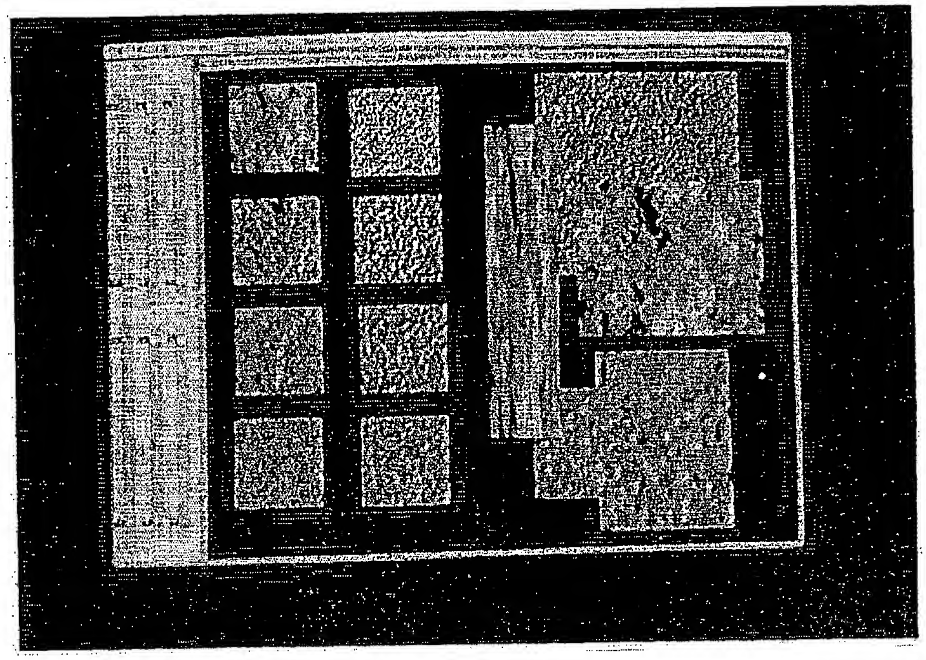
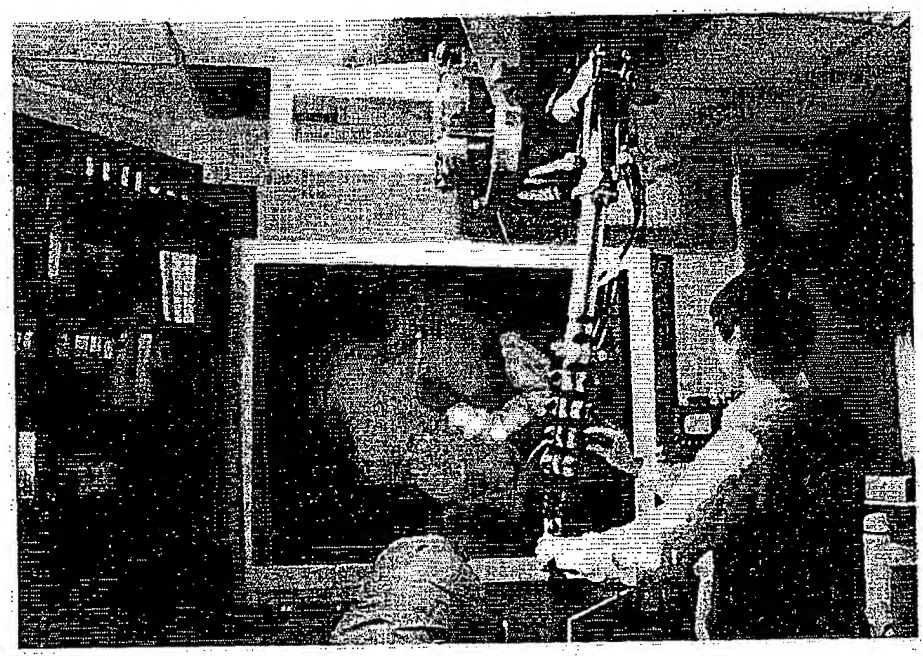
Color images for this paper can be found in the color plate section.



Color plate 1: The *Sandpaper* environment screen display. The patches have textures, animated objects, or materials in them. The user can feel these when holding and moving the force feedback joystick. The sliders on the left adjust the way each patch feels.



Color plate 2: The molecular docking system uses a master station of a remote manipulator system (ARM) as a 6-D force and torque interface. The purpose is to find the best fit of a drug inside a receptor molecule. The drug in white is methotrexate, an anti-cancer drug; the receptor in blue and red is dihydrofolate reductase, an enzyme.

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Legend

Abbreviation	Meaning
C	Cited in thesis
T	Used in thesis table

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A STUDY IN TWO-HANDED INPUT

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ABSTRACT

Two experiments were run to investigate two-handed input. The tasks selected were chosen to be representative of common tasks found in CAD and office information systems. In the experiments, the tasks assigned to each hand involved communicating continuous, rather than discrete, information.

Experiment one involved the performance of a selection/positioning task in which the selection and positioning sub-tasks were performed by separate hands using separate transducers. Without prompting, novice subjects adopted strategies that involved performing the two sub-tasks simultaneously. We interpret this as a demonstration that, in the appropriate context, users are capable of simultaneously providing continuous data from two hands without significant overhead. The results also show that, for the experimental task, that speed of task performance is strongly correlated to degree of parallelism.

Experiment two involved the performance of a navigation/selection task. It compared a one-handed versus two-handed method for finding and selecting words in a stylized document. The results show that, for the experimental task, the two-handed method significantly outperformed the common one-handed method by a number of measures. Unlike experiment one, only two subjects adopted strategies that used both hands simultaneously. The benefits of the two-handed technique, therefore, are interpreted as being due to efficiency of hand motion. However, the two subjects who did use parallel strategies had the two fastest times over all subjects.

INTRODUCTION

A researcher turns a page of a book while taking notes. A driver changes gears while steering a car. A recording engineer fades out the drums while bringing in the strings.

What each of these tasks has in common is that the human operator is assigning a continuous task to each hand. What is clear is that we all perform this type of task every day. What is less clear is why hardly any user interfaces allow us to utilize this demonstrated ability in communicating with a computer.

From our experience in building systems for music and graphics, we were convinced that tapping this

human ability could result in improvements in human performance for both experts and novices. Especially with the trend towards direct manipulation systems (Shneiderman, 1983), we were further convinced that such tasks were applicable beyond specialized applications such as process control and music.

In order to test our hypotheses, we designed and ran two experiments. The first has its roots in computer aided design, and involves what we call a positioning/scaling task. The task for the second experiment is drawn from word processing, and involves navigating through a document that is only partially visible through the display "window" (Myers, 1984).

In the first experiment we forced all subjects (all novices) to use two hands. In the second experiment we used both experts and novices to compare one-handed and two-handed methods for performing the navigation task. The one-handed method was based on the scrolling mechanism used by the Apple Macintosh MacWrite program (Apple, 1984). The two-handed method was of our own design.

EXPERIMENT 1: POSITIONING/SCALING

Introduction

In our first experiment we had subjects perform a compound task where they positioned a graphical object with one hand and scaled its size with the other. The task was designed so that it could be perfectly solved serially by first positioning the object, and then scaling it. In addition, in our instructions and training, we did everything to bias users to perform it in a sequential manner.

Our hypothesis was that when the positioning and scaling sub-tasks were split over two hands and two devices, that users would gravitate towards performing them both in parallel. Despite the tendency towards sequential task performance assumed by most computer systems, our belief was that, for the positioning/scaling task, parallel performance of the sub-tasks was more "natural". We also believed that the motor skills required to perform the task were either already existent, or easily acquired.

The Task

Subjects were presented two squares on a CRT. One square, known as the target, is positioned randomly on the screen and scaled to a random size. The other square is known at the tracker. The position of the tracker square is controlled by the subject's right hand using a graphics tablet with a puck. The size of the tracker is controlled by the subject's left hand using a treadmill-like slider. The task is for the subject make the tracker match the position and size of the target.

The squares were designed to be easily distinguished. The tracker was drawn with solid lines. The target was represented by its corners only, which appeared as bold lines. The centre of each square was indicated by an identical fixed-size cross. The squares can be seen in Figure 1, which shows the screen during an actual trial.

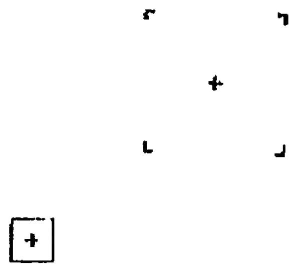

Figure 1: Experiment 1 Trial.

The target square is defined by bold corners. The tracker is the square defined by the solid lines. The goal is to position the tracker over the target and scale its size to match.

Scaling the tracker square was symmetrical in relation to its centre. Therefore, the two sub-tasks task could be performed sequentially by aligning the centre cross of the tracker square with that of the target, and then adjusting the tracker's size.

Trials began by the subject depressing a button on the tablet's puck. A trial automatically finished when the scaling and positioning were within a system-defined degree of tolerance. The end of each trial was signaled to the user by an audio beep from the computer. The final position of the tracker for trial n became its initial position for trial n+1. At the start of each trial, the target jumps to a new random position and assumes a new random size. Subjects could either hold the puck button down during a trial or click and release.

After training, subjects ran five sets of ten trials each. Sets were timed. At the end of each set, subjects were told their average time over that set as well as their own best time. Subjects were instructed to try to beat their best time. The total time taken by a subject to complete the experiment, including training and filling out a questionnaire, was about seventeen minutes.

The Environment

The experiment was run on a PERQ I workstation from PERQ Systems Corp. It features a high-resolution (1024 x 768) non-interlaced bit-mapped display. The aspect ratio of the CRT was rectangular, and it was vertically oriented in portrait style.

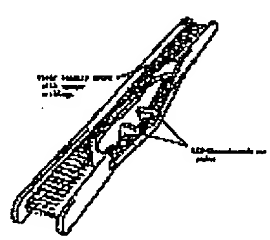

Figure 2: Cutaway view of an Allison Research Slider

The graphics tablet used was a Bit Pad-1 with a 4-button puck manufactured by Summagraphics Ltd. The tablet controlled the tracker in absolute mode so that there was a direct mapping of the position of the puck on the tablet to the position of the tracker on the screen.

The slider box was made at the at our Institute using a treadmill-like device developed by Allison Research of Nashville, Tennessee. The slider is, in effect, a 1-D mouse, providing relative information

proportional to the amount of motion up or down. The slider is about 13 cm by 2 cm. A cut-away schematic of the slider is shown in Figure 2.

The workstation was in an area isolated by office partitions. All subjects used the same configuration with the workstation keyboard removed, the sliders on the left and the tablet on the right. The test environment is shown in Figure 3.

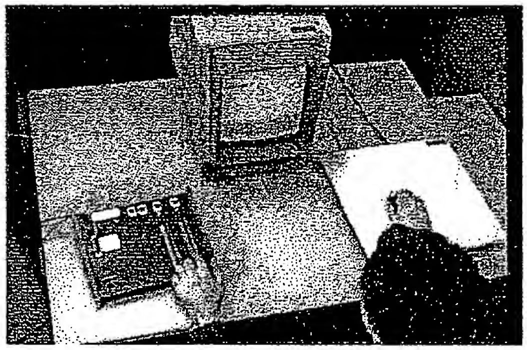

Figure 3: The Experimental Environment

Subjects

Fourteen subjects were used in the experiment. All were graduate students or staff associated with the Computer Systems Research Institute. Subjects were respondents to a call for volunteers posted in our building. Subjects were not paid, and none obtained course credit for their participation. Virtually all subjects were computer literate, some holding advanced degrees. However, all of the subjects were novices in the use of computer pointing devices.

Training

Subjects were trained for the experiment in two stages, corresponding to the positioning and scaling sub-tasks, respectively. It was our intent in the training not to do anything (beside provide a device for each hand) to bias toward using parallel strategies in the experimental task. For consistency, all instructions were provided in written form on-line.

The first training session involved a task identical to that used in the experiment, except that the tracker and target were the same size. Hence, there was no scaling involved. After reading the instructions, subjects performed the task in sets of 10 trials until they reached a specified standard of proficiency.

The second part of the training was to develop familiarity with the slider and the scaling task. In this case, both squares were centred on the screen. In sessions of 45 seconds, the target square continuously grew and shrank. The subject was instructed to continuously match the target's size with the tracker square using the slider. If a specified degree of proficiency was not reached after the first session, additional sessions were presented.

Following completion of the two stages of training (which typically took on the order of 5 minutes), instructions for the experimental task were presented. Of utmost importance is to note that at no time was a subject informed that both devices could be used at the same time. Furthermore, the sequencing of the two training sessions follows the sequence in which the task can be performed perfectly without any parallel activity.

Results

The most important result was that averaged over all trials, subjects were engaged in parallel activity 40.9% of the time. If we look at only the best session for each subject, the figure becomes 45.1%.

In order to see how they correlated, we plotted speed of task performance against percentage of time engaged in parallel activity. This data is shown in Figure 4.

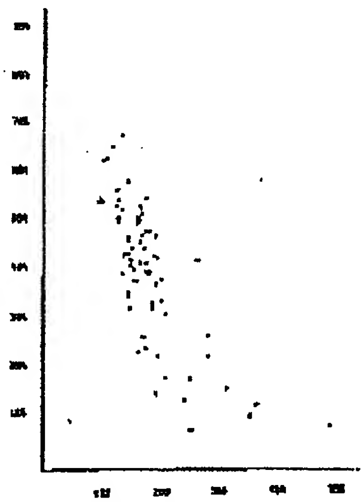

Figure 4: Time vs Parallel Activity

The horizontal axis represents time to complete the task (in 60ths of a second). The vertical axis represents percentage of time engaged in parallel activity. Average data for each session of each subject is plotted (5 x 14 = 70 points).

Of the 14 subjects, six used parallel strategies from the first trial. The others evolved to parallelism through the successive sessions.

Interpretation

Subjects clearly have no difficulty in performing the task. The high incidence of parallel activity suggests that neither of the two sub-tasks presented a significant load on the cognitive or motor systems. The experiment shows that the efficiency of subjects' performance correlates positively to the degree of parallelism used. Perhaps most important, we believe that the experiment demonstrates that such behaviour is natural, at least for the task presented. This we support by the subjects' unprompted adoption of parallel strategies.

EXPERIMENT 2: SELECTION/NAVIGATION

Introduction

Having established subjects' ability to utilize two hand effectively, we were then interested in determining if there were common transactions where a two-handed approach would result in significant improvements in performance when compared to common one-handed techniques. We chose a task

from word processing for the experiment. The task was to select specified words in a stylized document. The experiment was designed so that the subject had to navigate to the appropriate part of the document before selection could take place.

To establish a known frame of reference, we modeled the one-handed technique on the scroll arrows and scroll bar of MacWrite word processor (Apple, 1984). This we compared to a two-handed technique of our own design. MacWrite was chosen since it is representative of the current state-of-the-art. It also gave us access to a population of expert subjects.

Our hypothesis was that a well-designed strategy that partitioned the selection/navigation task between two hands would be easier to learn and use than the popular one-handed technique tested. Based on our previous experience, our belief was that complete novices using the two-handed technique would come close to matching the performance of experts using one hand.

The Task

The screen was partitioned into two halves. In the top half of the screen was a window 80 characters wide and 24 lines long. Part of a document was displayed within the window. In the bottom half of the screen, a one-line instruction was presented to the subject. Instructions were always to select a particular word on a particular line. Selection was always done using a puck on a graphics tablet. However, the specified word was never visible in the window at the time the instruction was given, so the user would have to navigate to the appropriate part of the document before selection could take place. Two different ways were used to navigate. Subjects were divided into two groups. One half used the puck and the MacWrite-like scroll bar and arrows. The other half used their left hand to navigate by manipulating two touch-sensitive strips.

A stylized document was used. It consisted of 60 numbered lines double-spaced. Lines were numbered in both the left and right margin. Each line contained three words: Left, Middle, and Right. The words were placed in three columns at the left, middle, and right of the lines. An example of what was presented to the subject is shown in Figure 5.

We chose this stylized document to better approximate the case where one is navigating within a familiar document. Subjects performed three sessions of 21 trials (resulting in 20 transitions per session). To better focus on operational issues, the same questions were presented in each of the three sessions.

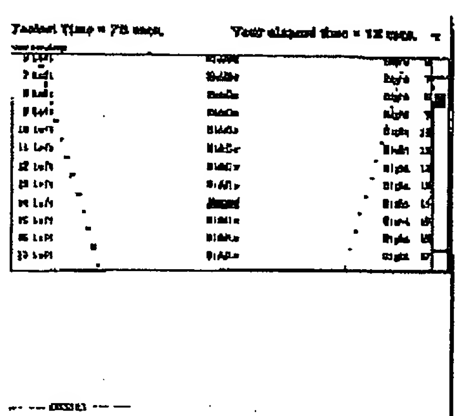

Figure 5: Sample Trial for Two-Handed Version.

The subject has just correctly selected line 14, Middle. The program has responded by instructing "Line 28, Left" to be selected. The current relative position in the document is indicated by the black bar in the scroll bar in the right margin of the window. In the two-handed version, the graphic scroll bar is for output only.

With both the one-handed and two-handed versions, there were two strategies that one could use to navigate. One was to smooth scroll, the other was to jump. With the one-handed version the scroll arrows were used to smooth scroll and the scroll bar to jump. With the two handed version, one touch-sensitive strip was used to scroll the document up or down. The second strip caused a jump to the same relative position in the document as the position on the strip that was touched (top->beginning, bottom->end, ...).

Subjects were timed and presented their average time and best time at the end of each session. They were instructed to try to beat their best time. The time required for subjects to complete their participation, including training and filling out a questionnaire was about twenty minutes.

The Environment

The environment used was the same as that described for Experiment 1. The only difference was that the slider box was replaced by a touch-sensitive tablet. The touch-sensitive surface and its controller were manufactured by Elographics Corp. The power supply and housing were of our own manufacture. The touch-tablet's surface was partitioned into two vertical strips by using a cardboard template. Each exposed strip measured about 4.5 cm by 2 cm. A photograph of the touch-tablet is shown in Figure 6.

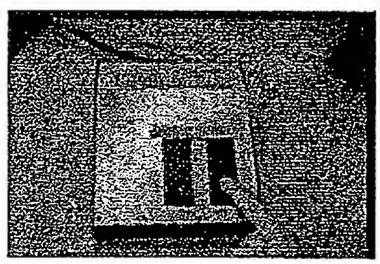

Figure 6: The Touch-Sensitive Tablet

The tablet surface is partitioned by a template into two virtual devices. The left one is a position-sensitive strip used to jump to specific locations in the document. The right one is a 1-D relative device used to smooth scroll the document in the window. See Buxton, Hill and Rowley (1985) for additional information on the use of touch-tablets.

Subjects

Twenty-four subjects ran the experiment. Twelve were experts in the use of a mouse and twelve were novices. Half of each group ran the one-handed version of the experiment, the other half ran the two-handed version. Hence, there were four groups of six subjects in a two-by-two comparison.

Subject expertise was determined via a questionnaire. The data generated in the experiment strongly

verifies our grouping of subjects. Subjects were staff or students (graduate and undergraduate) associated with the Department of Computer Science. Subjects were respondents to either posted or verbal calls for volunteers. No subjects were paid, and none obtained course credit for their participation.

Training

To maintain consistency, all training was done on-line. Subjects were presented the document and given instructions on how to use the particular navigational tools assigned to them. Different instructions were obviously provided to the two-handed and one-handed groups.

Results

The first result showed that the two-handed approach resulted in better performance by experts and novices alike.

1. Experts: the two-handed group out-performed the one handed group by 15%.
2. Novices: the two-handed group out-performed the one handed group by 25%.

Using the two-handed technique greatly reduced the gap between expert and novice users. If we look at the average times taken from the first set of trials, we see the following:

1. Using the one-handed approach, experts out-performed novices by 85% (p.0.05).
2. Using the two-handed approach, experts out-performed novices by only 32% (p 0.02)
3. Comparing experts using the one-handed technique and novices using the two-handed technique, experts out-performed novices by only 12%, and this difference has no statistical significance.

The data shows that from the very first set, there were significant improvements for novices and experts when using the two-handed technique.

If we look at times for subjects' best of three sets, we also see that the two-handed technique resulted in superior performance. The top six times were obtained by subjects using the two-handed technique. A comparison of the performance of the subjects by group is summarized in Figure 7.

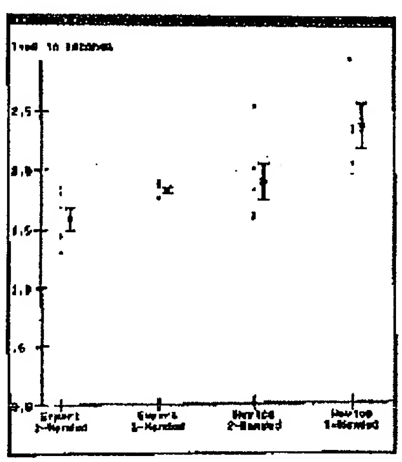

Figure 7: Subjects' Performance by Group (best set only)

Based on our results from experiment one, we expected to observe subjects using both hands in parallel (for example, moving the tablet puck from one side to the other while the target was being scrolled into view).
However, with the majority of users this was not the case. Only two subjects employed parallel strategies. Significantly, these two subjects had the two best times in the experiment.

Regarding strategies, all subjects jumped significantly more than smooth scrolled during searches, although the effect was more pronounced with experts. The data also shows that experts jumped far more when using the one-handed version than when using the two handed version (93% vs 74% of the time, respectively) in their best session.

Interpretation

The results show that the partitioning of the navigation/selection task between the two hands results in improved performance for experts and novices. The first order benefit cannot, however, be attributed to the two hands being used at once. Rather, the improvement is interpreted as being due to the increased efficiency of hand motion in the two-handed technique. In the one-handed approach, significant time is consumed in moving the pointer between the document's text and the navigational tools. In the two-handed version, the hands are always in home position for each of the two task, so no such time is consumed.

If this interpretation is correct, we would expect to see the greatest improvement in performance in transitions where there is greatest distance between the target and the navigational tools. This situation occurs in the one-handed technique where two selections occur in sequence on the left side of the display (remember, the scroll-bar and scroll-arrows are along the right margin of the display). This expectation was confirmed by the data. With such transitions, the two-handed technique resulted in performance improving by 30% . With transitions that minimized the movement between target and navigational tools (two targets appearing in sequence on the right side of the display), the improvement was reduced to 15%.

Unlike the experimental condition, in many real-world tasks, time is lost to homing with the two-handed technique as well. An example, would be where the hands frequently move back-and-forth from the keyboard. This may make the benefits of the technique of less practical significance overall. Note, however, that in such contexts, time is equally lost in homing with the one-handed technique.

Finally, we must address the question of why more simultaneous use of two hands was not observed. We can only conclude that the task in experiment two was more difficult than that in experiment one. It is important to remember, however, that despite the fact that the entire experiment took subjects less than twenty minutes, two did adopt a parallel strategy, and these two subjects obtained the best times overall. Consequently, while more difficult, the skill can be easily learned and performance benefits can accrue when it is.

CONCLUSIONS

The data generated makes a strong case for improving performance by splitting the sub-tasks of compound continuous tasks between the two hands. Experiment One shows that even novice users have the requisite manual skills, and Experiment Two shows that significant improvements can be made over

one-handed techniques which are the current practice.

Experiment Two shows that performance improvements can occur with two handed input even where the tasks are performed sequentially. Furthermore, by splitting the tasks between two hands, the foundation is laid for further improvement by the ability to support parallel task performance by more skilled users.

To date, very few computer systems easily lend themselves to experimentation with the types of interaction described in this paper. This may be largely due to the serial nature of existing programming languages and processors. Technological biases notwithstanding, we feel that the results reported here warrant increased attention being paid to an investigation of both multi-handed and parallel input structures.

ACKNOWLEDGEMENTS

We are indebted to a number of people for help in running this experiment. Dorothy Philips and Stu Card gave a great deal of help in the design of the positioning/scaling experiment. Christine Warchol wrote the first implementation of that experiment, although that version was never run due to a computer death. Guy Fedorkow built the slider box used in experiment one. Jan Venus constructed the touch-sensitive unit used in experiment two. Ralph Hill and the CHI'86 referees provided many useful comments. Liz Russ helped type and proof-read the manuscript. Finally, we are indebted to the students of the University of Toronto who volunteered as subjects.

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A HAND GESTURE INTERFACE DEVICE

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ABSTRACT

This paper reports on the development of a hand to machine interface device that provides real-time gesture, position and orientation information. The key element is a glove and the device as a whole incorporates a collection of technologies. Analog flex sensors on the glove measure finger bending. Hand position and orientation are measured either by ultrasonics, providing five degrees of freedom, or magnetic flux sensors, which provide six degrees of freedom. Piezoceramic benders provide the wearer of the glove with tactile feedback. These sensors are mounted on the light-weight glove and connected to the driving hardware via a small cable.

Applications of the glove and its component technologies include its use in conjunction with a host computer which drives a real-time 3-dimensional model of the hand allowing the glove wearer to manipulate computer-generated objects as if they were real, interpretation of finger-spelling, evaluation of hand impairment in addition to providing an interface to a visual programming language.

Resume

Cet article presente le developpement d'un systeme main-machine qui fournit en temps reel les positions, orientations et gestes de la main de l'utilisateur. L'element de base du systeme est un gant, l'ensemble du systeme utilisant differentes technologies: Des capteurs analogiques places sur le gant mesurent les flexions des doigts. La position et l'orientation de la main sont mesures, soit a l' aide d'un systeme ultrasonique, qui fournit cinq des degres de liberte du systeme, soit a l'aide d'un systeme magnetique, qui fournit es six degres de liberte. Des elements piezoceramiques places sur le gant sont controles pour fournir a l'utilisateur differentes sensations tactiles. Ces differents capteurs sont montes sont un gant de faible poids, connecte au systeme de controle par un cable de faible dimension.

Les applications du systeme comprennent son utilisation relie a un ordinateur contenant un modele temps reel en trois dimensions de la main permettant a l'utilisateur de manipuler des objets virtuels generes par l'ordinateur comme s'ils existaient reelement, l'interpretation de signes alphabetiques pour mal-entendants, l'evaluation clinique de troubles fonctionnels de la main, ainsi que son utilisation comme interface a un langage de programmation visuelle.

Keywords: Human Interface, User Interface, Motor Interface, Tactile Interface, Gesture Recognition.

1. INTRODUCTION

The hand gesture input devices presented here, the Z-Glove™ and the DateGlove™, are lightweight cotton gloves containing flex sensors which measure finger bending, positioning and orientation systems, and tactile feedback vibrators.

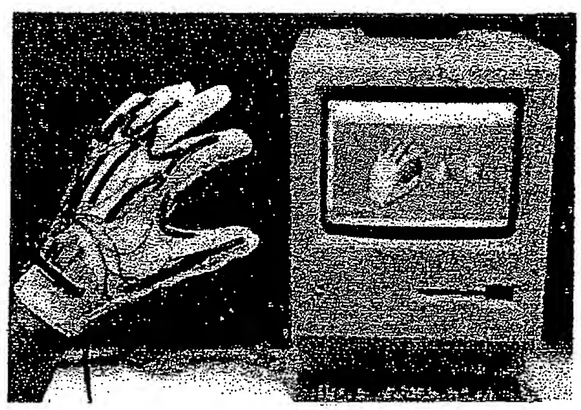

Figure 1.
DataGlove with outer glove removed to show sensors

Different orientation and positioning systems of the Z-Glove and the DataGlove distinguish the two models. The Z-Glove employs an ultrasonic positioning and orientation system controlled by a Commodore 64™ computer and is less costly and more limited in application. The DateGlove, using a magnetic positioning and orientation system controlled by an Apple Macintosh™ computer is more expensive and of wider application (see Fig. 1).

2. ELEMENTS OF THE SYSTEM

2.1 FLEX SENSORS

On both gloves, the flex sensor is a patented [Zim85] optical goniometer that can be manufactured in a variety of dimensions suited to the application. Flex sensors measuring two inches long by one quarter inch in diameter are glued to a tight-fitting, stretchable inner glove. Multiplexing electronics are mounted on top of the inner glove and protected by a loose-fitting outer glove.

Five to fifteen flex sensors are mounted on a glove, depending on the application. The finger joints measured are the metacarpophalangeal (MP or inner) joints, the proximal interphalangeal (PIP or middle) joints and their abductions, and the palm (see Fig. 2).

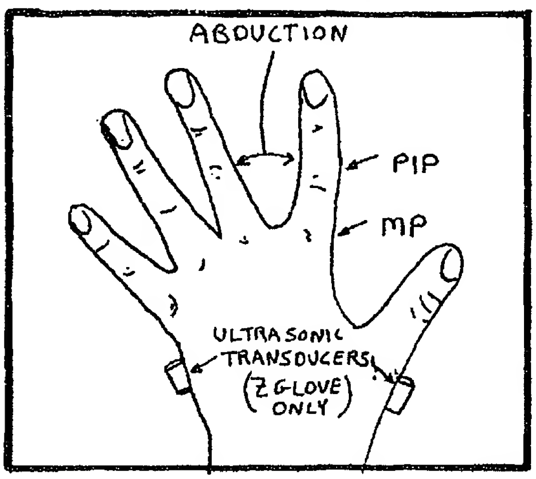

Figure 2
Flex and ultrasonic transducer placement

On the DataGlove, analog signals from the flex sensors are multiplexed to data-acquisition hardware which interfaces to an Apple Macintosh computer. On the Z-Glove, analog flex signals are fed directly to the internal converters of the Commodore 64 computer.

2.2 POSITIONING AND ORIENTATION

2.2.1 ULTRASONIC POSITIONING AND ORIENTATION

The positioning and orientation system on the Z-Glove consists of two ultrasonic transducers attached to opposite sides of the metacarpal (between the wrist and the fingers), a hardware timer, three ultrasonic receivers mounted around the perimeter of a monitor, and triangulation software running on a Commodore 64 computer. Processing overhead is reduced by using triangulation approximations. Visual feedback is provided by an icon which tracks hand movement, minimizing the impact of tracking errors.

Roll and yaw of the hand is determined from the position of the transmitter pair. The ultrasonic transmitters need a direct line-of-sight for their acoustic signals to reach the receivers. If one transmitter is blocked (by the fingers or part of the hand), orientation information is lost. If both transmitters are blocked, the tracking icon freezes.

Position jitter due to detection error is reduced, with minimum impact on response time, by means of a software filter that decreases the filtering with increasing hand velocity.

2.2.2 MAGNETIC POSITION AND ORIENTATION

On the DataGlove, a 3SPACE™ (Polhemus Navigation Sciences Division, McDonnell Douglas Electronics Company, Esses Junction, Vermont) position and orientation system is used. The 3SPACE uses low frequency magnetic fields to measure six degrees of freedom. The small 3SPACE sensor is mounted on the dorsal side of the hand between the glove's two layers. The 3SPACE is connected to one of the serial ports on the Apple Macintosh computer. The 3SPACE requires no filtering of data.

2.3 TACTILE FEEDBACK

Tactile feedback is used to add realism to interactions between computer-generated (virtual) objects and the virtual hand. Tactile cues are being experimented with to simulate object contact, hardness and surface texture.

Piezoceramic benders driven with a 20-40 Hz sine wave, (below peak sensitivity of 250 Hz [Sherrick82] to prevent audible sound generation) are mounted underneath each finger. The sensation produced is "tingling" or "numbness".

Benders are used because of their small size, low cost and low operating voltage. Frequency modulation is used to vary the intensity of the tactile sensation and to minimize the finger "numbing" sensation. Tactile stimulation is increased by driving benders closer to peak tactile sensitivity frequency. Object contact is cued when virtual fingertips touch the surface of virtual objects. Contact is signaled by oscillating finger benders, which produce a "buzzing" sensation at the fingertips.

3. GESTURE RECOGNITION AND CALIBRATION

Representing and recognizing human hand gestures is a deep problem analogous to the recognition of human

speech or handwriting. We present here some of the basic methods of gesture recognition.

It is possible to identify two types of gestures: object manipulations (eg: pick up, rotate, throw, squeeze), and commands (eg: draw a line, produce a sound, set a color). Gestures can also be classified as static (eg: a "victory" or a "peace" sign), or dynamic (eg: waving good-bye).

Z-Gloves and DataGloves are manufactured in several sizes taking into account the wide variety of human hands. Individual gesture styles further complicate gesture recognition. Two techniques of calibration have been developed to compensate for these variations.

3.1 MANUAL CALIBRATION

Manual calibration is a method in which a subject wearing the Z-Glove performs tasks. One manual calibration method requires the Z-glove wearer to grab a series of objects placing finger joints at known angles. The joint bending angles recorded in this manual calibration are used in a clinical study of hand rehabilitation.

A finger spelling interpretation application uses manual calibration to form gesture templates. Gesture recognition is performed by differentiating finger values with values from such gesture templates. The absolute value of these differences is summed for each gesture template. The gesture with the minimum sum is chosen if that sum is less than a confidence threshold. If the gesture does not match any of the templates closely enough then the gesture is ignored.

3.2 AUTOMATIC CALIBRATION

Gesture recognition using automatic calibration scales flex sensor values by recording mimimum and maximum joint extension values. The maximum values are decremented over time to prevent an extreme joint extension from skewing the scaling of recorded values. Hysteresis thresholds unique to each finger are applied to reduce the position of the fingers to quantized states. These finger states are then compared to gesture templates containing permissable finger states and the first successful gesture template match is chosen, or "recognized". Threshold values and gesture templates are user-independent and are empirically derived.

Unintentional passing (transitional) gestures are "debounced" by requiring a valid gesture to be held for a period of time.

Dynamic gesture recognition techniques are being investigated. As in speech recognition, dynamic gesture recognition is able to take advantage of context in order to limit the number of gestures to be distinguished at a given time.

4. A VISUAL PROGRAMMING LANGUAGE INTERFACE

A Z-Glove based user interface is explored in a visual programming environment known as Grasp™ (originally called Mandala) under development at VPL Research, Inc. [Lanier84]. The Grasp system runs on microcomputers and uses the ultrasonic positioning and orientation system.

A moving hand-shaped icon tracks the user's hand. When a valid gesture is detected, the hand image is shown performing that gesture. This produces a discrete animation of a hand, rather than a continuous representation of the hand.

In most mouse (or other pointing device) based interfaces, there are two phases to each user action: selection of an object, and selection of the operation to be performed on the selected object. In Grasp, object selection and operation are accomplished simultaneously by gesturing over an object.

In order to make gestures easier to learn and remember, gestures in Grasp are analogous to real-world gestures. A "grab" (all fingers closed like a fist) picks up an object. Once picked up, the object can be carried around the screen and "dropped" (all fingers opened) at a new location. If the user merely opens a few fingers, a copy of the object is put down. If the user picks up an object with only the thumb and index finger, a value is "plucked" from the object. Opening fingers quickly over an objects opens or expands the object.

5. APPLICATIONS

Among the present applications of the DataGlove and the Z-Glove are a gesture recognition device, a clinical tool for evaluating hand function, a three-dimensional hand model controller, an interface to a visual programming language, a music and sound synthesis controller, a finger spelling interpreter, and a computer-generated object manipulator. Future projections for DataGlove and Z-Glove applications lie in the fields of robotics, human factors and ergonomics research.

5.1 THREE-DIMENSIONAL HAND MODEL

A flexible, three-dimensional, articulating hand model is constructed using local coordinates for each finger joint, represented by a linked list of records, with each finger having a full range of angular motion. The hand model (virtual hand) is generated in real time using the DateGlove and the Apple Macintosh computer (see photo).

5.2 A CLINICAL HAND IMPAIRMENT MEASURING TOOL

Hand impairment measurements are classified as anatomical and functional. A goniometer obtains anatomical measurements by measuring the range of

motion of a given joint. Functional tests measure the time it takes to perform common unilateral tasks like stacking checkers, turning over cards, or putting small objects in a can [Jebsen69].

The process of measuring the range of motion of a patient's hand by a skilled therapist with a mechanical goniometer can take one to two hours and is only repeatable to within five degrees if the same physical therapist with a mechanical goniometer performs the measurements [Rosen86]. The DataGlove has the capability of measuring a patient's range of motion in a fraction of the time, under the supervision of a less skilled assistant, with more repeatable results. Tests are now being conducted to examine this application.

Functional tests like the Jebsen Hand Function Test take a considerable amount of time for the patient and the physical therapist. Dynamic data recorded on video tape is also time consuming to analyze. The DataGlove, with a positioning and orientation system, is being investigated as a means of logging and analyzing functional tests.

5.3 THREE-DIMENSIONAL OBJECT MANIPULATION

Manipulating three-dimensional virtual objects with two-dimensional controllers such as digitizing tablets, touch pads and mice are awkward since these objects are capable of six-dimensional movement. Both the Z-Glove and DataGlove (with a positioning and orientation system) allow users to interact with virtual objects much as they do with real objects. Virtual objects can be picked up, grabbed, twisted, squeezed, thrown, and set down.

A virtual object can be moved (translated and rotated) with either the Z-Glove or the DataGlove while it is being operated on (eg: squeezed and twisted). And since simultaneous actions are usually faster than sequential ones [Buxton86], the entire function can be performed in a more natural, more efficient manner.

The Z-Glove and the DataGlove address the question of "scoping", the selection of a subset from a set. This is significant when several objects appear near or on each other. Consider a computer-generated image of cherries in a glass bowl viewed from the side. When using a mouse to point at a cherry, it is ambiguous whether one is pointing to the cherry or the bowl. In contrast, one could use the DataGlove or the Z-Glove to close one's fingers around and pick up the desired item, without ambiguity. A handful of cherries, for that matter, could be picked up, the number of cherries in the handful being a function of the size of the grasp.

A virtual environment project at NASA Ames Research Center [Fisher86] uses a head-mounted, three-dimensional display [Sutherland68], a DataGlove, and a 3SPACE TRACKER in current research directed toward eventual control of a remote robot band. The hand performs operations in an environment hostile to human life (in space or under conditions which, due to radiation or other factors, is dangerous), while the operator remains protected and comfortable (inside a space capsule or safe enclosure).

6. CONCLUSION

Two systems, the DataGlove and the Z-Glove, have been presented both of which allow the direct manipulation of computer-generated objects.

The best type of interface device performs its task unobtrusively. A joystick is a controller that a user acts upon. The DataGlove and the Z-Glove, on the other hand, are articles of clothing which instrument the user's actions. The user's hand is the controller, as is natural for it to be.

Just as speech is our natural means of communication, the human hand is our natural means of manipulating the physical world. As computer systems begin to simulate the physical world, the technologies presented in this paper suggest a broad spectrum of possibilities to a wide variety of users. It is increasingly important that we shape the simulated world of the computer in ways which reflect our human universe, rather than allow ourselves to be shaped by our machines.

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